GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

REVISED MINUTES

of the 5th Meeting of the Standing Committee of

X ACADEMIC COUNCIL

Day & Date

Tuesday, 14th February, 2023 & Thursday, 23rd February, 2023

Time

10.00 a.m.

Venue
Council Hall,
Administrative Block
Goa University

D 3.12	**Minutes of the Board of Studies in Portuguese meeting held on 18.10.2022.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Portuguese meeting held on 18.10.2022 with the suggestion to thoroughly verify the translation of titles/font in languages before uploading the Syllabus on the website. **(Action: Assistant Registrar Academic-PG)**
D 3.13	**Minutes of the Board of Studies in Biochemistry meeting held on 22.10.2022.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Biochemistry meeting held on 22.10.2022 with the suggestion to replace terminology 'Text Books/References/Readings' with 'References/Readings.' **(Action: Assistant Registrar Academic-PG)**
D 3.14	**Minutes of the Board of Studies in Philosophy meeting (by circulation)** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Philosophy meeting held by circulation with the following suggestions: 1. Prerequisites for the Course PYTC 601 – Research Methodology to be added. 2. Pedagogy for the Course to be included. **(Action: Assistant Registrar Academic-PG)**
D 3.15	**Minutes of the Board of Studies in Biotechnology meeting held on 13.10.2022.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Biotechnology meeting held on 13.10.2022 with the following suggestions: 1. Heading 'Elective Generic Course' mentioned under Course Structure to be replaced with 'Generic Elective Course'. 2. Course level listed below the Course structure to be deleted. 3. The syllabus to be submitted as per prescribed syllabus template. 4. Number of hours of the Course Code GBTR-502, Bioprocess Technology to be corrected. 5. Course Code of the Course Scuba Diving to be verified. **(Action: Assistant Registrar Academic-PG)**
D 3.16	**Minutes of the Board of Studies in Marathi meeting held on 19 and 20.10.2022.** The Standing Committee of the Academic Council approved the minutes of the Board of Studies in Marathi meeting held on 19.10.2022 and 20.10.2022 with the following suggestions: 1. Title of the Courses to be indicated in both Marathi and English languages. 2. Translation of titles/font in languages to be thoroughly verified before uploading on the website. Hon'ble Vice-Chancellor (Chairperson) thanked Prof. K. S. Bhat on behalf of the Academic Council for his cooperation and contribution to the academic progress of

Std. Com. X AC-5
14.02.2023

GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

F I N A L A G E N D A

For the 5th Meeting of the Standing Committee of

X ACADEMIC COUNCIL

Day & Date

Tuesday, 14th February, 2023

Time

10.00 a.m.

Venue
Conference Hall
Administrative Block
Goa University

	4. MGPE 012-Women and Peace (SWAYAM Course) **SEMESTER IV (Annexure II Refer page No.558)** **Research Specific Elective Courses** 1. PYTE 509-Philosophy of Buddhism 2. PYTE 510-Philosophy of Religion **Discipline Specific Compulsary Course** 1. PYDT-Dissertation **The BOS has also approved the syllabus of the Ph.D. course work on Research Methodology. (Annexure III Refer page No. 564)** 1. PYTC 601-Research Methodology. The declaration by the Chairman, that the minutes were circulated by the Chairman. Date: 28.10.2022 Sd/- Place: School of Sanskrit, Philosophy and Indic Studies, Goa University Signature of the Chairman of BOS **Part G:** Remark of the Dean of faculty: The minutes are in order: Recommended for approval of Academic Council Date: 28.10.2022 Sd/- Place: School of Sankrit, Philosophy and Indic Studies, Goa University Signature of the Dean, SSPIS **(Back to Index)**
D 3.15	**Minutes of the Board of Studies in Biotechnology meeting held on 13.10.2022.** **Part A** i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: **N. A.** ii. Recommendations regarding courses of study in the subject or group of subjects at the postgraduate level: **1. Approve the Semester III and Semester IV courses for the M.Sc. Biotechnology and M.Sc. Marine Biotechnology programme. (Annexure I Refer page No. 566) and (Annexure II Refer page No. 594)** **2. Research Methodology Course for Ph.D. Biotechnology. (Annexure III Refer page No. 620)** **3. List of examiners for the B.Sc. Biotechnology Programs.** **Part B** i. Scheme of Examinations at undergraduate level:N.A. ii. Panel of examiners for different examinations at the undergraduate level: Panel of examiners submitted in sealed envelope. iii. Scheme of Examinations at postgraduate level: **N.A.** iv. Panel of examiners for different examinations at post-graduate level: **N.A.**

Part C.

i. Recommendations regarding preparation and publication of selection of reading material in the subject or group of subjects and the names of the persons recommended for appointment to make the selection. N.A.

Part D

i. Recommendation regarding general academic requirements in the Departments of University or affiliated colleges.N.A.
ii. Recommendations of the Academic Audit Committee and status thereof: **N.A.**

Part E

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

Part F

Important points for consideration/ approval of Academic Council

i. The important points/recommendations of BoS that require consideration/approval of Academic Council (points to be highlighted) as mentioned below
   a. **Semester III and Semester IV courses for the M.Sc. Biotechnology and M.Sc. Marine Biotechnology programme.**
   b. **Research Methodology Course for Ph.D. Biotechnology.**
   c. **List of examiners for the B.Sc. Biotechnology Programs.**

The declaration by the chairman that the minutes were readout by the Chairman at the meeting itself.

Date: 19.10.2022
Place: School of Biological Sciences & Biotechnology, Goa University. Sd/-
Signature of the Chairman

Part G. The Remarks of the Dean of the faculty

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

Date: 19.10.2022
Place: Goa University

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D 3.16 — **Minutes of the Board of Studies in Marathi meeting held on 19 and 20.10.2022.**

Part A

i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: NIL
ii. Recommendations regarding courses of study in the subject or group of subjects at the postgraduate level: **(Annexure I Refer page No. 623)**

D 3.15 Minutes of the Board of Studies in Biotechnology meeting held on 13.10.2022.

Annexure I

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

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

Course level 100: NO prerequisite for the course except for the basic admission eligibility .
Course level 200: At least **ONE** prerequisite course is required.
Course level 300: At least **TWO** prerequisite courses are required.
Course level 400: Courses from Semesters I, II, III are prerequisites.

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SEMESTER III

Course Code:	GBTR-501	
Title of the Course	RECOMBINANT DNA TECHNOLOGY	
Credits	3	
Prerequisite:	GBTC-407 , GBTC-409, GBTE-401, GBTC-403 (Any Two courses)	
Objective:	The students will understand the use of • various enzymes and techniques for manipulating DNA. • various DNA vectors and their use in creating recombinant DNA molecules • recombinant DNA modification techniques and heterologous gene expression used for creating applications for biological research and biotechnology industries	
Learning Outcomes	The students will be able to • create recombinant DNA molecules and evaluate their expression. • Exploit relevant tool/techniques as well as vector and host for cloning and expression. • Design experiments for generating applications for use in medical animal and plant biotechnology.	
Contents:	**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; 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.	15 hours

	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; proof reading 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 hrs
	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 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	15 hours
Pedagogy	Lectures, tutorials, assignments	

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

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Course Code:	GBPR-501	
Title of the Course	LAB VII: Recombinant DNA Technology	
Credits	2	
Prerequisite	GBTR 501 AND GBPC-407, GBTC-409, GBPC-404, GBPC-401 (Any two Courses)	
Objective:	The students will learn • Understand cloning strategies and expression of foreign genes • setting up reactions for DNA manipulation. • to interpret the results of DNA manipulation studies and use appropriate tools for the validation of recombinant DNA.	
Learning Outcomes	The student will be able to • Create recombinant DNA molecules. • Conceptualize the various steps in cloning DNA in an appropriate vector and evaluate gene expression. • Apply and use the knowledge to create tools in diagnostics, medical and forensic science	
Contents:	**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	30 hours
	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 hrs
Pedagogy	Hands-on experiments in the laboratory, online videos.	
References/ Readings	1) Carson, S. (2006) Manipulation and expression of recombinant DNA a laboratory manual Elsevier Academic Press 2) Green, M.R and Sambrook J. (2012) Molecular Cloning: A Laboratory Manual Three-volume CSH Press 3) Vennison J.S. (2009) Laboratory Manual for GENETIC ENGINEERING. PHI Learning	

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Course Code:	GBTR-502	
Title of the Course	Bioprocess Technology	
Credits	3	
Prerequisite	GBTC 401, GBTE 401, GBTC 403 (Any two courses)	
Objective:	• To educate students about fundamental concepts of bioprocess technology and its related applications,	
Learning Outcomes	• Preparing them to meet the challenges of new and emerging areas of biotechnology industry	
Contents:	**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.	15 hours 15 hours
	MODULE II **Industrial production of chemicals:** • Strain improvement for increased field & other desirable characteristics • alcohol (beer) • organic acids (citric acid)	15 hrs

	• antibiotics (Penicillin) • amino acids (lysine) • Application of microbes in food processing: 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 hrs
Pedagogy	Lectures, tutorials, assignments	
References/Readings	1) Cassida, L.E. (1994). Industrial microbiology. New Age International Pvt Ltd Publishers. 2) Coulson, J.M. & Richardson, J.F. (2017) Chemical engineering. Elsevier. 3) Dordick, J. S. (Ed.). (2013). Biocatalysts for industry. Science & Business Media. 4) Flickinger, M.C. & Drew, S.W.(1999). Encyclopedia of Bioprocess technology. Vol 1-5. 5) Fomina, M., & Gadd, G. M. (2014). Biosorption: current perspectives on concept, definition and application. Bioresource technology, 160, 3-14. 6) Trevan, M.D. (1980). Immobilized enzymes: An introduction & application in biotechnology. 7) Kuila, A. & Sharma, V. (Eds.)(2018). Principles and Applications of Fermentation Technology. John Wiley & Sons. 8) Najafpour, G. (2015). Biochemical engineering and biotechnology. Elsevier. 9) Prasad, K. K. & Prasad, N. K. (2010). Downstream process technology: a new horizon in Biotechnology. PHI Learning Pvt. Ltd. 10) Prave, P., Fanst, V., Sitting, W. & Sukatesh, D.A. (1987). Fundamentals of Biotechnology. 11) Stanbury, F., Whitaker, A., Stephan, J.H. (2003) Principles of fermentation technology.Butterworth Heinemann Books - Elsevier 12) Wiseman, A. (Ed). (1984). Topics in enzyme Fermentation technology. Topics in enzyme and fermentation biotechnology. ACS Publications 13) Young, M. M.(Ed) (2019) Comprehensive Biotechnology.Pergamon Press.	

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Course Code:	GBPR-502	
Title of the Course	Lab VIII: Bioprocess technology	
Credits	2	
Prerequisite	GBPC-401, GBPC-404	
Objective:	The objectives of this laboratory course is/are • to educate students about fundamental concepts of bioprocess technology • to provide hands-on training to students in upstream and downstream unit operations.	
Learning Outcomes	On completing of this course, students should be able to: • appreciate relevance of microorganisms from industrial context; • carry out stoichiometric calculations and specify models of their growth; • give an account of design and operations of various fermenters; • present unit operations together with fundamental principles for basic methods in production techniques for bio-based products; • calculate yield and production rates in biological production process, and also interpret data; • give an account of important microbial/enzymatic industrial processes in the industry	
Contents:	**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	30 hrs
	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 hrs
Pedagogy	Hands-on experiments in the laboratory, online videos.	
References/ Readings	1. Behrens, D. & Kramer, P.(Ed). (1990) Bioprocess engineering: Downstream processing & recovery of bioproducts, safety in biotechnology and regulations. 2. Cassida, L.E. (1994). Industrial microbiology. New Age International Pvt Ltd Publishers.	

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

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Course Code:	GBPR-503	
Title of the Course	Lab IX: Environmental Biotechnology	
Credits	2	
Objective:	• To impart students with the hands-on experience in basic experimental analysis and the use of biological agents. • To understand emerging treatment processes carried out for the wastewater and organic solid waste analysis	
Learning Outcomes	The students will be able to carry out • an analysis of municipal wastewater and organic solid waste analysis. • Able to understand the process of organic waste treatment.	
Contents:	**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	30 hrs
	MODULE II (Analysis of wastewater)	30 hrs

	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	
Pedagogy	Hands-on experiments in the laboratory, online videos.	
References/ Readings	1) APHA. (2005) "Standard Methods for Examination of Water and Wastewater", American Public Health Association WWA, Washington, D.C. 2) Angelidaki I , Alves M, Bolzonella D, Borzacconi, L. Campos, J.L., Guwy, A.J., Kalyuzhnyi, S., Jenicek P., and Van Lier, J.B., (2009) Defining the Biomethane Potential (BMP) of Solid Organic Wastes and Energy Crops: A Proposed Protocol for Batch Assays. Water Science & Technology.	

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Course Code:	GBTG-501
Title of the Course	Solid Waste Management
Credits	3
Objective:	• To develop required skills in Plan segregation, collection, transportation, recycling and disposal of municipal solid waste • 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. • Provide relevant information about municipal solid waste reduction and on hazardous waste management.
Learning Outcomes	At the end of this course, the students will be able to: • explain solid waste management systems with respect to its physical properties, and associated critical considerations in view of emerging technologies. • outline sources, types and composition of solid waste with methods of handling, sampling and storage of solid waste. • select the appropriate method for solid waste collection, transportation, redistribution, disposal and treatment. • describe methods of disposal of hazardous solid waste.

Contents:	**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 hours
	MODULE II • Handling, Separation and Storage of Solid Waste: • -Handling and separation of solid waste at site. Material separation by pick in, screens, float and separator magnets and electromechanical separator and other latest devices for material separation. • -Waste handling and separation at Commercial and industrial facilities. • -Storage of solid waste at the sources. • Processing of Solid Waste: • -Processing of solid waste at residence e.g. Storage, conveying, compacting, Shredding, pulping, granulating etc. • -Processing of solid waste at Commercial and industrial site.	15 hours
	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.	15 hrs

	-Hazardous waste toxicity, reactivity, infectiousness, flammability, radioactivity, corrosiveness, irritation, bio-concentration, genetic activity, explosiveness. -Bio-medical waste, its sources, generation, storage, transportation and Disposal. • Solid waste management and sustainable development: Case studies	
Pedagogy	Lectures, tutorials, Case studies, assignments	
References/ Readings	1. Chaterjee, A. K. (2011). Introduction to environmental biotechnology. PHI, India 2. Davis M. L. David A.(2017). Environmental Engineering. McGraw Hill Education 3. George T. Hillary T., and Samuel V. (2014). Integrated solid waste management . McGraw Hill Publisher. 4. Henstock M.E. (1983). Disposal and recovery of municipal solid waste Butterworths publication 5. King, R. B., Sheldon, J. K. and Long, G. M. (1998). Practical Environmental Bioremediation: The Field Guide, Lewis Publishers. 6. Prabhu, M. 2016. Resource recovery from wastewaters for sustainable development. shodhganga.inflibnet.ac.inhttp://hdl.handle.net/10603/84904 7. Satyanarayana, T., Johri, B. and Anil, T., (2012). Microorganisms in Environmental Management, Springer Publishers. 8. Scragg A. (2007).Environmental Biotechnology. Pearson Education Limited. 9. Rehm H J and Reed G, (1999) Biotechnology, a comprehensive treatise, VCH Verleg.	

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Course Code:	GBTG-502
Title of the Course	IPR, BIOSAFETY AND BIOETHICS
Credits	3
Objective:	To provide basic knowledge on intellectual property rights and their implications in biological research and product development; • To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products; • To become familiar with ethical issues in biological research. • Understand the consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing.
Learning Outcomes	On completion of this course, students should be able to: • understand the rationale for and against IPR and especially patents; • understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations; • understand different types of intellectual property rights

	• gain knowledge national and international regulations of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of GMOs	
Contents:	**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 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.	15 hrs
	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; 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). • 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 hrs
Pedagogy	Lectures, tutorials, Case studies, assignments	
References/ Readings	1. Bently L, Sherman B. (2008) Intellectual property law . Oxford University Press. 2. Bently Lionel (2008) Intellectual property law Oxford University Press. 3. Complete Reference to Intellectual Property Rights 4. Cook T. M. (2007). A User's Guide to Patents Tottel Publishing. 5. Craig, W., Tepfer, M., Degrassi, G., &Ripandelli, D. (2008). An Overview of General divisions/csurv/geac/annex-5.pdf F. (2009). Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9 6. Features of Risk Assessments of Genetically Modified Crops. Euphytica 7. Fleming, D. O. Hunt D L (2000) Biological safety: principles and practices ASM Press. 8. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.	

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11. International Union for the Protection of New Varieties of Plants. http://www.upov.int
12. Joshi Rajmohan.(2006) Biosafety and bioethics Gyan Publishing House.
13. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences – Case Studies of Policy Challenges from New Technologies, MIT Press
14. Keith F (2000) CRC handbook of laboratory safety. A.CRC Press.
15. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.
16. Laws. (2007). Snow White Publication Oct.
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, (2017) Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from https://dbtindia.gov.in/
22. Singh, K. (1993). Intellectual property rights in Biotechnology. A status report New Delhi Biotech Consortium, India.
23. Sreenivasulu, N.S. and Raju C.B. (2008) Biotechnology and Patent laws: patenting living beings Manupatra Publishers.
24. Wegner H (1994) Patent law in Biotechnology, chemicals & pharmaceuticals. Stockton Press
25. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J.W., Burachik, M., Gray, A., Wu, World Intellectual Property Organisation.
26. World Health Organization (2004). Laboratory biosafety manual. WHO press.
27. World Trade Organisation. http://www.wto.org

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Course Code:	GBTG-503
Title of the Course	Food technology
Credits	2
Objective:	The student will learn • the various method of food processing, storage and maintenance. • to evaluate the safety and quality standards
Learning Outcomes	On completion of this course, • students should be able to acquire knowledge and contribution of biotechnology in food industry.
Contents:	**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	15 hrs
	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, economic importance, nutrition promotion, consumer studies qualitative and quantitative research methods.	15 hrs
Pedagogy	Lectures, tutorials, assignments	
References/ Readings	1. Evans, G. M., Furlong, J., Evans, G. G. (2011). Environmental Biotechnology: Theory and Application. United Kingdom: Wiley. 2. Fatma T. (1999). Cyanobacterial and Algal Metabolism and Environmental Biotechnology. India: Narosa. 3. Fingerman, M. (Ed.). (2003). Recent Advances in Marine Biotechnology, Vol. 8: Bioremediation (1st ed.). CRC Press. 4. Frazier W.C., Westhoff D.C., Vanitha V.M. (2017)Food Microbiology. 5th Edition. McGraw Hill Education 5. Galvez Raul P, Berge Jean-Pascal(Eds.) (2013).Utilization of Fish Waste. United Kingdom: CRC Press. 6. Hall, G. M. (2012). Fish Processing Technology. United Kingdom: Springer US. 7. Ninawe A.S. Rathnakumar K. (2008). Fish Processing Technology and	

	Product Development. Narendra Publishing House. India 8. Omura S (2011) The search for bioactive compounds from microorganisms.Springer New York

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Course Code:	GBTG-506	
Title of the Course	Virology	
Credits	2	
Objective:	Upon completion of this course, • 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 • Gain an appreciation for viruses as essential drivers of the evolution of life on Earth. • theoretical knowledge in virology virus transmission processes, illness and aetiology	
Learning Outcomes	The student will be able to • the identify the different viral diseases and corelate with the virus morphology, classification and containment facilities • able to employ methodology to study the diversity of unculturable viruses. • devise applications such as phage therapy for combating infections	
Contents:	**MODULE I** • General Virology • The structure of virus particles : subunits , filamentous viruses and nucleoproteins ,isometric virus particles , Enveloped (membrane-bound) virus particles , Virus particles with head–tail morphology • Frequency of occurrence of different virus particle morphologies • Classification of viruses based on disease , host organism , virus particle morphology , viral nucleic acids , taxonomy. • Satellites, Viroids, and prions • Replication of Viral DNA and RNA • Containment facilities, maintenance and handling of pathogenic viruses • Viral Enteric Diseases and Oncogenic viruses, Rotavirus diversity, emerging strains, • Other viruses associated with diarrhoea and gastroenteritis: Adenoviruses, • astroviruses, Norwalk and Sapporo-like viruses and other enteroviral diseases.	15 hrs

	• 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 hrs
Pedagogy	Lectures, tutorials, Case studies, Assignments	
References/ Readings	1. Ananthanarayan, R. (2020). Ananthanarayan and Paniker's Textbook of Microbiology. Universities Press. 2. Carter, J., Saunders, V. A. (2007). Virology: principles and applications. Wiley. 3. Dimmock, N. Easton, A. Leppard , K. (2006) Introduction to Modern Virology. John Wiley and Sons. 4. Flint, J. Enquist L,W, et al (2000)Principles of Virology: Molecular Biology, Pathogenesis, and Control. ASM Press 5. Khare, R. ((2019) Guide to Clinical and Diagnostic Virology, ASM Books. 6. Korsman, S. N. J., Andersson, M. I., Nutt, L., Van Zyl, G., Preiser, W. (2012). Virology E-Book: An Illustrated Colour Text. Elsevier Health Sciences. 7. Kudesia, G., Wreghitt, T. (2009). Clinical and Diagnostic Virology. Cambridge University Press. 8. Mishra, B. (2020).Textbook of Medical Virology. CBS Publishers and Distributors 9. Richman D.D., Hayden F.G., Whitley R. J., (2020). Clinical Virology. Wiley. 10. Skalka, A. M., Flint, J., Rall, G. F., Racaniello, V. R., Hatziioannou, T. (2020). Principles of Virology. Wiley.	

	11. Warom, R. (2017) Virology. Titan Books 12. White, D. O., Fenner, F. J. (2016). Medical Virology. Elsevier Science. 13. Woolverton, C. J., Sherwood, L., Willey, J. (2016). Prescott's Microbiology. McGraw-Hill Education.

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Course Code:	GBTG-507	
Prerequisites	Basic knowledge in Molecular biology , Biochemistry, Bioinformatics	
Title of the Course	GENOMICS AND PROTEOMICS	
Credits	2	
Objective:	• 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 • To provide basic knowledge about sample preparation, mass spectrometry workflow, different chromatography technologies and quantitative proteomics.	
Learning Outcomes	• Students should be able to acquire knowledge and understanding of the fundamentals of genomics and proteomics, transcriptomics and metabolomics. • Able to understand and appreciate the applications in various areas of biology/medical field	
Contents:	**MODULE I** **Genomics** • 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.	15 hrs
	MODULE II **Proteomics** • 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 hrs
Pedagogy	Lectures, tutorials, assignments	
References/ Readings	1. Ann Batiza (2005) Bioinformatics, genomics, and proteomics: getting the big picture. Infobase Publishing, 2. Benjamin Cummings (2007) Bioinformatics, 2nd Edition. 3. Glick BR & Pasternak J.J, (1998) Molecular Biotechnology, 3rd Edition, ASM Press, 4. Kobe B., Gussand M. Huber T. Campbell A.M &Heyer L.J (2008)- Structural Proteomics: High-Throughput Methods (Methods in Molecular Biology) Discovering Genomics and Proteomics, Humana Press 5. Liebler, D.C. (2002), Introduction of Proteomics: Tools for the new Biology. Totowa, NJ: Humana Press. 6. Suhai S.C(2000) Genomics and proteomics: functional and computational aspects Springer.	

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Course Code:	GBTG-508
Title of the Course	Emerging trends in wastewater treatment
Credits	2
Objective:	The primary objectives of the course are as follows: • Reinforcing the basic tenets of microbial treatment of wastewaters and waterborne pathogens (source, fate and factors affecting their survival in the environment). • Understanding the advantages and disadvantages between centralized wastewater systems, decentralized systems and onsite systems and appropriate application of each of these systems. • Understanding of emerging and novel biological treatment technologies and how these technologies need to be modified to address site specific conditions. • Gain insights into the use of biological treatment processes used to recover valuable constituents or produce valuable products from wastewaters. • Understanding of microbial or molecular based technologies used to

	monitor for the presence, sources and types of contaminants discharged in complex wastewater mixtures	
Learning Outcomes	At the end of this course, students will be • able to understand the basic tenets of biological wastewaters treatment, the advantages and disadvantages between centralized and decentralized systems. • able to gain insights into the processes to recover or produce valuable products from wastewater. • Able to understand emerging treatment strategies that combine both conventional biological approaches with emerging technologies in hybridized systems • exposed to how biological monitoring can be integrated with water quality monitoring to enhance our understanding of how wastewaters are impacting ecosystem health,	

Contents:	**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, agricultural, domestic)
	• Impact of increasing complexity in the composition of wastewater on treatment strategies
	• Challenges in treatment of wastewater
	
	Decentralized Wastewater Treatment Systems
	• 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
	
	Conventional Biological Treatment Processes
	• Overview of conventional biological treatment
		15 hrs

	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	15 hrs

	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 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. Chaterjee, A K, (2000), Introduction to environmental biotechnology. PHI, India. 2. Colin, M. (2012). Marine Microbiology: Ecology and applications. Second edition. Garland science. 3. Satyanarayana, T., Johri, B. and Anil, T., (2012). Microorganisms in Environmental Management, Springer Publishers. . 4. Kennish, M. J. (2019). Practical Handbook of Estuarine and Marine Pollution. CRC Press, Francis and Taylor. 5. King, R. B., Sheldon, J. K. and Long, G. M. (1998). Practical Environmental Bioremediation: The Field Guide, Lewis Publishers. 6. Meena, S.M and Naik, M.M. (2019). Advances in Biological Science Research: a practical approach. Elsevier. 7. Prabhu, M. (2016). Resource recovery from wastewaters for sustainable development. shodhganga.inflibnet.ac.in http://hdl.handle.net/10603/84904.

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SEMESTER IV

Course Code:	GBTR-504
Title of the Course	RESEARCH METHODOLOGY
Credits	2
Objective:	The aim of this course is 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. • The course will give the student an overview of research methods.
Learning Outcomes	At the end of this course, • students will be able to understand basic elements of scientific research including research methods, research planning, writing research proposal, data collection and analysis and writing scientific communications.

Contents:	• **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 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.	15 hrs
	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.	15 hrs

	• 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.	
Pedagogy	Lectures, tutorials, assignments	
References/ Readings	1. Alley, M., (1996). The Craft of Scientific Writing, Springer Science and Business Media. 2. Barbara Gastel and Day R.A. (2016). How to write and publish a scientific paper. Greenwood. 3. Cooray P.G. (1992). Guide to Scientific and Technical Writing. P.G. Cooray, Hindagala, Sri Lanka, 4. Kothari C. R., (2004). Research Methodology Methods and Techniques, New Age International. 5. Kumar, R. C., (2008). Research Methodology. APH Publ Corporation, New Delhi. . 6. Shamoo, A. E. and Rasnik D. B. (2015). Responsible conduct of research. Oxford University Press, New York.	

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Course Code:	GBTR-505	
Title of the Course	SYNTHETIC BIOLOGY	
Credits	2	
Prerequisite	GBTC-407, GBTC 408, GBTR-501(Any Two)	
Objective:	The objective of course is to • redesign organisms for useful purposes by engineering them to have new abilities. • harness the power of nature to solve problems in medicine, manufacturing and agriculture.	
Learning Outcomes	The students will be able to understand • apply the concepts of synthetic biology for the design of biological systems. • how the limits of existing technology be overcome by DNA synthesis technology • and identify the biological problems that have limitations for industrial use and to analyze how synthetic biology can be applied as a solution.	
Contents:	**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	15 hrs
	Module II • Genome editing: CRISPR technologies, gene therapy, synthetic immunology • Artificial cells, Synthetic genomics, *Mycoplasma laboratorium*, Protocell • Computational method for protein engineering, pathway engineering, circuit designs using biological parts for creating synthetic biological constructs and strain design • Xenobiology using nucleic acid analogues, xenonucleic acids, unnatural base pairs and expanded genetic code • Applications of synthetic biology in biosensors, biological computers, organoids, bio-printed organs, space explorations. • Ethics on creation of life and ethical support for synthetic biology	15 hrs
Pedagogy	Lectures, tutorials, assignments	
References/Readings	1. Andrea M M (2018) Introduction to Synthetic Biology Springer Verlag 2. Covert M. W.(2018) Fundamentals Of Systems Biology From Synthetic Circuits To Whole-Cell Models Taylor & Francis 3. Davies J. A (2018) Synthetic Biology: A Very Short Introduction Oxford 4. Kaebnick G. E. , Murray T. H. , Lustig A ,Boldt J (2013) Synthetic Biology and Morality Artificial Life and the Bounds of Nature MIT Press Ltd 5. Marchisio, M.A (2021) Computational Methods in Synthetic Biology Springer 6. Singh V., Dhar P.K. (2015) Systems and Synthetic Biology. Springer	

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Course Code:	GBTR-506
Title of the Course	PLANT AND ANIMAL BIOTECHNOLOGY
Credits	2
Prerequisite	GBTC-406, GBTC-407, GBTC-408, GBPC 410 (Any two)
Objective:	The course is designed to provide a • comprehensive exposure to advances in animal and plant

	biotechnology. • Student is expected to have a clear understanding of basic biotechnology techniques to learn recent advances in the field	
Learning Outcomes	• Students will learn to combine previously acquired knowledge of biotechnology to understand the advance application in human welfare.	
Contents:	**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 live stock, Ethics of cloning Disease resistant transgenics, animal models for disease study, Pharming, improving milk quality, improving traits, Xenografts, Toxological applications, knock outs	15 hrs
	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 cultures for secondary metabolite production; Production of pharmaceutically important compounds; Bioenergy generation	15 hrs
Pedagogy	Lectures, tutorials, assignments	
References/Readings	1. Bongso A. and Lee E.H .(2004) Stem cells from bench to bed side World Scientific publisher 2. Denis M., (2007), Plant Breeding and Biotechnology: Societal Context and the Future of Agriculture,Cambridge University Press, 3. Gupta P. K. 2015. Plant Biotechnology. Rastogi Publication. 4. Jordan B.R,(2006) The Molecular Biology and Biotechnology of Flowering, CABI Publication 5. Neil W., (2007) Phytoremediation: Methods and Reviews, Humana Press,. 6. Singh B. D. 2015. Plant Biotechnology. Kalyani Publisher. 7. Slater A., Scott N., and Fowler ., (2003), Plant Biotechnology: The genetic manipulation of plants. Oxford University Press,	

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Course Code:	GBSR-501
Title of the Course	SCUBA DIVING
Credits	2

Prerequisite	Students must know to swim 200 meters (any style) and be able to float 10 minutes	
Objective:	Skill-based course with an objective to • Familiarize divers with knowledge, procedures, techniques, and problems of underwater diving. • Appreciate and preserve marine life .	
Learning Outcomes	• Will be able to do underwater surveying. • Collection of underwater marine samples • Can enrol for advanced scuba diving course	
Contents:	**Module I** Dive Theory • Introduction • Diving equipment • Physics • Physiology • Planning dives • Executing dives • The underwater world • Scuba experience and beyond	15 hrs
	Module Two Practicals (Total 4 dives) • 2 sessions of pool training for skills • 2 days of 2 sea dives each - skills and pleasure dives	15 hrs
Pedagogy	Lectures, tutorials, practical onsite training	
References/Readings	1) PADI (2015) PADI Open Water Diver Manual PADI publisher 2) Graver, D. (2016) Scuba Diving. Human Kinetics Publishers 3) Cole, S. and Brandon M. (2013) Reef Life: A Guide to Tropical Marine Life Firefly Books Ltd	

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Annexure II

M.Sc. Marine Biotechnology (1455)
(Applicable from 2022-23)

Course Codes	Course Titles	Credits	Course Level
Semester III			
Research Specific Elective courses (Any 8 credits)			
MBTR-501	Recombinant DNA Technology	3	300
MBPR-501	Lab VII: Recombinant DNA Technology	2	300
MBTR-502	Bioprocess Technology	3	300
MBPR-502	Lab VIII: Bioprocess technology	2	300
MBTR-503	Marine Food Technology	2	200
Elective Generic courses (Any 12 credits)			
MBTG-501	Virology	2	100
MBTG-502	IPR, Biosafety & Bioethics	3	100
MBTG-503	Potential of Marine Biotechnology	2	300
MBTG-504	Genomics & Proteomics	2	200
MBTG-505	Solid Waste Management	3	100
MBIG-501	Summer/Winter Internship	2	100
Semester IV			
Research specific Elective courses (Any 4 credits)			
MBTR- 509	Research Methodology	2	100
MBTR-510	Synthetic Biology	2	300
MBTR-511	Plant and Animal Biotechnology	2	300
MBFR-501	Field Trip	2	100
MBSR-501	Scuba Diving	2	100
Discipline-specific dissertation			
MBPD- 501	Dissertation	16	400

Course level 100: No prerequisite for the course, except for the basic admission eligibility .
Course level 200: At least **one** prerequisite course is required.
Course level 300: At least **two** prerequisite courses are required.
Course level 400: Courses from Semesters I, II, and III are prerequisites.

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SEMESTER III

Course Code:	MBTR-501	
Title of the Course	RECOMBINANT DNA TECHNOLOGY	
Credits	3	
Prerequisite:	GBTC-407 , GBTC-409, GBTE-401, GBTC-403 (Any Two courses)	
Objective:	The students will understand the use of • various enzymes and techniques for manipulating DNA. • various DNA vectors and their use in creating recombinant DNA molecules • recombinant DNA modification techniques and heterologous gene expression used for creating applications for biological research and biotechnology industries	
Learning Outcomes	The students will be able to • create recombinant DNA molecules and evaluate their expression. • Exploit relevant tool/techniques as well as vector and host for cloning and expression. Design experiments for generating applications for use in medical animal and plant biotechnology.	
Contents:	**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; 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.	15 hours
	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; proof reading 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 hrs
	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; • Creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems e.g. fruit flies (Drosophila), worms (C.elegans),Frog (xenopus), 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	15 hours
Pedagogy	Lectures, tutorials, assignments	
References/ Readings	1) Brown T.A., (2016) Gene Cloning and DNA Analysis: An Introduction. Wiley-Blackwell Publishers 2) Brown, T. A. (2017). Genomes. New York: Garland Science Publisher 3) Dale, J,W. von Schantz M.,and Nicholas Plant (2011) From Genes to Genomes: Concepts and Applications of DNA Technology. Wiley-Blackwell publisher 4) Das H.K (2017) Textbook of Biotechnology Wiley Publisher 5) Green, M. R., & Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual.CSH Press.	

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<tr><td></td><td colspan="2">6) Hunter V.,and Strickland F., (2018). Applications of Recombinant DNA Technology. ED-TECH Press
7) Nair A.J (2008) Introduction to Biotechnology and Genetic Engineering. Laxmi Publications Pvt. Ltd
8) Primrose, S. and Twyman, R., B. (2006). Principles of Gene Manipulation and Genomics, Blackwell Publishing Limited.
9) Sarwar M K, Khan I A, Barp.D. (2016) Applied Molecular Biotechnology: The Next Generation of Genetic Engineering CRC Press.
10) Singh, V., and Dhar P (2020) Genome Engineering via CRISPR-Cas9 System. Elsevier Publisher</td></tr>
<tr><td>Course Code:</td><td colspan="2">MBTR-501</td></tr>
<tr><td>Title of the Course</td><td colspan="2">LAB VII: Recombinant DNA Technology</td></tr>
<tr><td>Credits</td><td colspan="2">2</td></tr>
<tr><td>Prerequisite</td><td colspan="2">GBPC-407, GBTC-409, GBPC-404, GBPC-401 (Any Two Courses)</td></tr>
<tr><td><u>Objective:</u></td><td colspan="2">The students will learn to
• understand cloning strategies and expression of foreign genes
• setting up reactions for DNA manipulation.
• to interpret the results of DNA manipulation studies and use appropriate tools for the validation of recombinant DNA.</td></tr>
<tr><td>Learning Outcomes</td><td colspan="2">The student will be able to
• Create recombinant DNA molecules.
• Conceptualize the various steps in cloning DNA in an appropriate vector and evaluate gene expression.
• Apply and use the knowledge to create tools in diagnostics, medical and forensic science</td></tr>
<tr><td>Contents:</td><td><u>MODULE I</u>
• 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
<u>MODULE II</u>
• Cloning of insert in to 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, 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.</td><td>30 hours

30 hrs</td></tr>
<tr><td>Pedagogy</td><td colspan="2">Hands-on experiments in the laboratory, online videos.</td></tr>
</table>

References/Readings	1) Carson, S. (2006) Manipulation and expression of recombinant DNA a laboratory manual Elsevier Academic Press 2) Green, M.R and Sambrook J. (2012) Molecular Cloning: A Laboratory Manual Three-volume CSH Press 3) Vennison J.S. (2009) Laboratory Manual for GENETIC ENGINEERING. PHI Learning

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Course Code:	MBTR-502	
Title of the Course	Bioprocess Technology	
Credits	3	
Prerequisite	MBTC401, MBTE-401, MBTC-403 (Any two courses)	
Objective:	• To educate students about fundamental concepts of bioprocess technology and its related applications,	
Learning Outcomes	• Preparing them to meet the challenges of new and emerging areas of the biotechnology industry	
Contents:	**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.	15 hours
	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: manufacture of cheese and monosodium glutamate	15 hrs
	Module III Downstream Processing: • Introduction, removal of microbial cells & solids bioseparation, filtration, centrifugation,	

	sedimentation. flocculation, cell disruption, liquid-liquid extraction. • Purification by chromatographic techniques • Drying and crystallization. • Storage & Packaging. • Effluent treatment & disposal. • Immobilization of microbial cells , immobilized reactors & their applications • Bioprocess for the production of biomass: yeast and mushrooms	15 hrs
Pedagogy	Lectures, tutorials, assignments	
References/Readings	1. Cassida, L.E. (1994). Industrial microbiology. New Age International Pvt Ltd Publishers. 2. Coulson, J.M. & Richardson, J.F. (2017) Chemical engineering. Elsevier. 3. Dordick, J. S. (Ed.). (2013). Biocatalysts for industry. Science & Business Media. 4. Flickinger, M.C. & Drew, S.W.(1999). Encyclopedia of Bioprocess technology. Vol 1-5. 5. Fomina, M., & Gadd, G. M. (2014). Biosorption: current perspectives on concept, definition and application. Bioresource technology, 160, 3-14. 6. Trevan, M.D. (1980). Immobilized enzymes: An introduction & application in biotechnology. 7. Kuila, A. & Sharma, V. (Eds.)(2018). Principles and Applications of Fermentation Technology. John Wiley & Sons. 8. Najafpour, G. (2015). Biochemical engineering and biotechnology. Elsevier. 9. Prasad, K. K. & Prasad, N. K. (2010). Downstream process technology: a new horizon in Biotechnology. PHI Learning Pvt. Ltd. 10. Prave, P., Fanst, V., Sitting, W. & Sukatesh, D.A. (1987). Fundamentals of Biotechnology. 11. Stanbury, F., Whitaker, A., Stephan, J.H. (2003) Principles of fermentation technology.Butterworth Heinemann Books - Elsevier 12. Wiseman, A. (Ed). (1984). Topics in enzyme Fermentation technology. Topics in enzyme and fermentation biotechnology. ACS Publications 13. Young, M. M.(Ed) (2019) Comprehensive Biotechnology.Pergamon Press.	

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Course Code:	MBPR-502
Title of the Course	Lab VIII: Bioprocess technology
Credits	2
Prerequisite	MBPC-401, MBPC-404
Objective:	The objective of this course is/are

<table>
<tr><td></td><td colspan="2">

- to educate students about fundamental concepts of bioprocess technology.
- to provide hands-on training to students in upstream and downstream unit operations

</td></tr>
<tr><td>Learning Outcomes</td><td colspan="2">On completing of this course, students should be able to:

- appreciate relevance of microorganisms from industrial context;
- carry out stoichiometric calculations and specify models of their growth;
- give an account of design and operations of various fermenters;
- present unit operations together with fundamental principles for basic methods in production techniques for bio-based products;
- calculate yield and production rates in biological production process, and also interpret data;
- give an account of important microbial/enzymatic industrial processes in the industry

</td></tr>
<tr><td rowspan="2">Contents:</td><td>

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

</td><td>30 hrs</td></tr>
<tr><td>

MODULE II

- Use of fermentor with special reference to scale-up operations.
- Microfiltrations: separation of cells from broth
- Bioseparations: Chromatography and extractions (organic acid & antibiotic)
- Manufacture of ginger ale and estimating the alcohol content.
- Solid State Fermentation: Mushroom cultivation.
- Food Microbiology: Preparation of an edible fermented product

</td><td>30 hrs</td></tr>
<tr><td>Pedagogy</td><td colspan="2">Hands-on experiments in the laboratory, online videos.</td></tr>
<tr><td>References/ Readings</td><td colspan="2">

1. Behrens, D. & Kramer, P.(Ed). (1990) Bioprocess engineering: Downstream processing & recovery of bioproducts, safety in biotechnology and regulations.
2. Cassida, L.E. (1994). Industrial microbiology. New Age International Pvt Ltd Publishers.
3. Coulson, J.M. & Richardson, J.F. (2017) Chemical engineering. Elsevier.
4. Flickinger, M.C. & Drew, S.W.(Ed). (1999) Encyclopedia of bioprocess technology. Vol 1-5. Wiley Blackwell

</td></tr>
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5. Khramtsov, N., McDade, L., Amerik, A., Yu, E., Divatia, K., Tikhonov,A., & Henck, S. (2011). Industrial yeast strain engineered to ferment ethanol from lignocellulosic biomass. Bioresource Technology, 102(17), 8310-8313.
6. Korzybski, T., Kowszyk-Gindifer, Z., & Kurylowicz, W. (2013). Antibiotics: origin, nature and properties. Elsevier.
7. Moser, A. (2012). Bioprocess technology: kinetics and reactors. Springer Science & Business.
8. Ngo, T. T. (Ed.). (2013). Molecular interactions in bioseparations. Springer Science & Business.
9. Prave, P., Fanst, V., Sitting, W. & Sukatesh, D.A. (Ed.)(1987) Fundamentals of Biotechnology. Saras Publications
10. Ray, B., & Bhunia, A. (2013). Fundamental food microbiology. CRC press.
11. Stanbury, F. & Whitaker, A. (2016) Principles of fermentation technology. Elsevier
12. Tamang, J. P. (Ed.). (2015). Health benefits of fermented foods and beverages. CRC Press.
13. Trevan, M.D. (1980) Immobilized enzymes: An introduction & application in Biotechnology. Wiley Blackwell
14. Wiseman, A. (Ed). (1984) Topics in enzyme & Fermentation technology. British Polymer Journal, Wiley Blackwell.
15. Young, M. (Ed) (1985) Comprehensive Biotechnology. Vol 2-4. Elsevier.

Course Code:	MBTR-503	
Title of the Course	Marine Food Technology	
Credits	2	
Prerequisite	MBTC-401	
Objective:	The objectives of this course are • to teach the principles of food preservation, processing and packaging. • quality management practices for food of marine origin.	
Learning Outcomes	On completion of this course, • students should be able to acquire practical knowledge of food technology for marine foods.	
Contents:	**MODULE I** • Introduction; Importance; Applications of biotechnology in food processing • Preservation and processing – chilling methods, phenomena of rigor mortis, spoilage changes- causative factors; Drying – conventional methods; Salt curing, pickling and smoking; Freezing and cold storage, Canning procedures; Role of preservatives in processing. • Packing – handling fresh fish, frozen packs, individually quick frozen (IQF), layered and shatter packs; Fishery by-	15 hrs

	products, cannery waste, feeds, silage, fish gelatin, fish glue, chitin and chitosan, pearl essence, fertilizer.	
	MODULE II • Seafood microbiology, factors influencing microbial growth and activity; Seafood borne pathogens: bacteria, fungi, viruses; Spoilage factors in seafood; • Toxins influencing food spoilage; Microbes as food single cell protein (SCP), microbial neutraceuticals. Quality management – concepts, planning, system, quality control, quality assurance, quality improvement; • Certification standards – ISO and HACCP; Principles of quality related to food sanitation, contamination, pest control, human resource andoccupational hazards; • Novel product development, marketing and sea food export – Marine Products Export Development Authority (MPEDA), government policies, economic importance; nutrition promotion, consumer studies qualitative and quantitative research methods.	15 hrs
Pedagogy	Lectures, tutorials, assignments	
References/ Readings	1. Omura S (2011) The search for bioactive compounds from microorganisms.Springer New York 2. Fingerman, M. (Ed.). (2003). Recent Advances in Marine Biotechnology, Vol. 8: Bioremediation (1st ed.). CRC Press. https://doi.org/10.1201/9781482279986. 3. Evans, G. M., Furlong, J., Evans, G. G. (2011). Environmental Biotechnology: Theory and Application. United Kingdom: Wiley. 4. Fatma T. (1999). Cyanobacterial and Algal Metabolism and Environmental Biotechnology. India: Narosa. 5. Ninawe A.S. Rathnakumar K. (2008). Fish Processing Technology And Product Development. India: Narendra Publishing House. 6. Galvez Raul P, Berge Jean-Pascal(Eds.) (2013).Utilization of Fish Waste. United Kingdom: CRC Press. 7. Frazier W.C., Westhoff D.C., Vanitha V.M. (2017)Food Microbiology. 5th Edition. McGraw Hill Education 8. Hall, G. M. (2012). Fish Processing Technology. United Kingdom: Springer US. 9. Kitts D, Shahidi F, JonesY. M. (2014) Seafood Safety, Processing and Biotechnology. Taylor and Francis. A CRC press book 10. Badapanda K.C. (2012). Fish Processing and Preservation Technology. Vol IV	

	NPH Narendra Publishing House, New Delhi

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Course Code:	MBTG-501	
Title of the Course	Virology	
Credits	2	
Objective:	The objectives of this course is to • 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 • gain an appreciation for viruses as essential drivers of the evolution of life on Earth. • theoretical knowledge in virology virus transmission processes, illness and aetiology	
Learning Outcomes	The student will be able to • the identify the different viral diseases and corelate with the virus morphology, classification and containment facilities • able to employ methodology to study the diversity of unculturable viruses. • devise applications such as phage therapy for combating infections	
Contents:	**MODULE I** • General Virology • The structure of virus particles : subunits , filamentous viruses and nucleoproteins ,isometric virus particles , Enveloped (membrane-bound) virus particles , Virus particles with head–tail morphology • Frequency of occurrence of different virus particle morphologies • Classification of viruses based on disease , host organism , virus particle morphology , viral nucleic acids , taxonomy. • Satellites, viroids, and prions • Replication of Viral DNA and RNA • Containment facilities, maintenance and handling of pathogenic viruses • Viral Enteric Diseases and Oncogenic viruses Rotavirus diversity, emerging strains, • Other viruses associated with diarrhoea and gastroenteritis: Adenoviruses,Astroviruses, 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	15 hrs

	• 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 hrs
Pedagogy	Lectures, tutorials, Case studies, assignments	
References/ Readings	1. Ananthanarayan, R. (2020). Ananthanarayan and Paniker's Textbook of Microbiology. Universities Press. 2. Carter, J., Saunders, V. A. (2007). Virology: principles and applications. Wiley. 3. Dimmock, N. Easton, A. Leppard , K. (2006) Introduction to Modern Virology. John Wiley and Sons. 4. Flint, J. Enquist L,W, et al (2000)Principles of Virology: Molecular Biology, Pathogenesis, and Control. ASM Press 5. Khare, R. ((2019) Guide to Clinical and Diagnostic Virology, ASM Books. 6. Korsman, S. N. J., Andersson, M. I., Nutt, L., Van Zyl, G., Preiser, W. (2012). Virology E-Book: An Illustrated Colour Text. Elsevier Health Sciences. 7. Kudesia, G., Wreghitt, T. (2009). Clinical and Diagnostic Virology. Cambridge University Press. 8. Mishra, B. (2020).Textbook of Medical Virology. CBS Publishers and Distributors 9. Richman D.D., Hayden F.G., Whitley R. J., (2020). Clinical Virology. Wiley. 10. Skalka, A. M., Flint, J., Rall, G. F., Racaniello, V. R., Hatziioannou, T. (2020). Principles of Virology. Wiley. 11. Warom, R. (2017) Virology. Titan Books 12. White, D. O., Fenner, F. J. (2016). Medical Virology. Elsevier Science. 13. Woolverton, C. J., Sherwood, L., Willey, J. (2016). Prescott's Microbiology. McGraw-Hill Education.	

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Course Code:	MBTG-503

Title of the Course	Potentials of Marine Biotechnology	
Credits	2	
Prerequisite	MBTC-401, MBTC 405, MBTC 406 (Any two)	
Objective:	The objective of this course is to • impart knowledge of biotechnological applications of marine organisms, important processes and • impacts on the marine ecosystems and ways to control them.	
Learning Outcomes	On completion of the course, • students should be able to comprehend the uses of marine organisms, their significances, interactions, impacts • develop management technologies to come up with solutions for their sustainability.	
Contents:	**MODULE I** • Marine viruses and Giruses • Giant bacteria and their significance • Unculturable bacteria : occurrence ,characteristics and exploitation • Barophilic organisms & their applications • Seaweeds for removal of metal pollutants • GFP, RFP characteristics and their applications • Green mussel adhesive protein • Chitosan : products and applications • Biomimetics	15 hrs
	MODULE II • Marine pollution • Biofouling and corrosion • Ballast water • Harmful algal blooms • Bacterial & viral pathogens in aquaculture • Aquaculture diseases and diagnosis	15 hrs
Pedagogy	Lectures, tutorials, assignments	
References/ Readings	1. Ahmed, S., Ikram, S. (2017). Chitosan:Derivatives, composites and applications. Wiley, Scrivener Publishing. 2. Bar-Cohen, Y. (2006). Biomemetics: Biologically Inspired Technologies. CRC Press. 3. Day, R., Davidson, M. (2014). The Fluorescent Protein Revolution. CRC Press. 4. Evams, G et al. (2003). Environmental Biotechnology. John Wiley & sons, Ltd. 5. Evans et al. (2000). Environmental BiotechnologyTheory and Application. Wiley- Blackwell. 6. Flemming, H.C., Murthy, P.S., Venkatesan, R., Cooksey, K.E. (2009). Marine and Industrial Biofouling. Springer. 7. Hicks, B. (Ed.) (2002). Green Fluorescent Protein. Humana Press. 8. Le Gal, Y., Ulber, R., & Antranikian, G. (2005). Marine Biotechnology. Springer.	

	9. Liengen, T., Basséguy, R., Féron, D., Beech, I.B. (2015). Understanding Biocorrosion. Elsevier Ltd. 10. Munn, C. (2011). Marine microbiology: Ecology & applications. Garland Science. 11. Nabti, E. (2017). Biotechnological Applications of Seaweeds. Springer. 12. Naik, M., Dubey, S. (2017). Marine pollution and microbial bioremediation. Springer. 13. Okaichi, T. (2003). Red Tides. Terra Scientific Publishing company, Tokyo and Kluwer Academic Publishers, Boston. 14. Osborn, M. and Smith, C. (2005). Molecular microbial ecology. Taylor & Francis. 15. Pillay, T. V. R. (2001). Aquaculture: Principles and Practices. Blackwell Pub., Oxford, UK. 16. Rainey, F., Oren, A. (2006). Extremophile Microorganisms and the Methods to Handle Them. Methods in Microbiology. Elsevier, Academic Press. 17. Swain, P. el al. (2006). Fish and Shellfish Immunology. Elsevier.

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Course Code:	MBTG-502
Title of the Course	IPR, BIOSAFETY & BIOETHICS
Credits	3
Objective:	• To provide basic knowledge on intellectual property rights and their implications in biological research and product development; • To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products; • To become familiar with ethical issues in biological research. • Understand the consequences of biomedical research technologies such as cloning whole organisms, genetic modifications, DNA testing.
Learning Outcomes	On completion of this course, students should be able to: • understand the rationale for and against IPR and especially patents; • understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations; • understand different types of intellectual property rights • gain knowledge national and international regulations of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of GMOs

Contents:	**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 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.	15 hrs
	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,	15 hrs

	compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools. • International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).	
	Module III • Introduction, ethical conflicts in biological sciences - interference with nature Bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis genetic screening, gene therapy, transplantation. • Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare • Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. • Sharing benefits and protecting future generations • Protection of environment and biodiversity • Biopiracy	15 hrs
Pedagogy	Lectures, tutorials, assignments	
References/ Readings	1. Bently L, Sherman B. (2008) Intellectual property law . Oxford University Press. 2. Bently Lionel (2008) Intellectual property law Oxford University Press. 3. Complete Reference to Intellectual Property Rights 4. Cook T. M. (2007). A User's Guide to Patents Tottel Publishing. 5. Craig, W., Tepfer, M., Degrassi, G., &Ripandelli, 6. D. (2008). An Overview of General divisions/csurv/geac/annex-5.pdf F. (2009). 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. Features of Risk Assessments of Genetically Modified Crops. Euphytica 8. Fleming, D. O. Hunt D L (2000) Biological safety: principles and practices ASM Press. 9. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub. 10. Grubb P. W. Grubb P. L. Thomsen, P. R. (2010),Patents for Chemicals, Pharmaceuticals and Biotechnology: Fundamentals of Global Law, Practice and Strategy Oxford University Press. 11. http://www.wipo.int	

	12. International Union for the Protection of New Varieties of Plants. http://www.upov.int 13. Joshi Rajmohan.(2006) Biosafety and bioethics Gyan Publishing House. 14. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences – Case Studies of Policy Challenges from New Technologies, MIT Press 15. Keith F (2000) CRC handbook of laboratory safety. A.CRC Press. 16. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell. 17. Laws. (2007). Snow White Publication Oct. 18. National Biodiversity Authority. http://www.nbaindia.org 19. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI, 20. National Portal of India.http://www.archive.india.gov.in 21. 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/ 22. Recombinant DNA Safety Guidelines, (2017) Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from https://dbtindia.gov.in/ 23. Singh, K. (1993). Intellectual property rights in Biotechnology. A status report New Delhi Biotech Consortium, India. 24. Sreenivasulu, N.S. and Raju C.B. (2008) Biotechnology and Patent laws: patenting living beings Manupatra Publishers. 25. Wegner H (1994) Patent law in Biotechnology, chemicals & pharmaceuticals. Stockton Press 26. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J.W., Burachik, M., Gray, A., Wu, World Intellectual Property Organisation. 27. World Health Organization (2004). Laboratory biosafety manual. WHO press. 28. World Trade Organisation. http://www.wto.org

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Course Code:	MBTG-504
Prerequisites	Basic knowledge in molecular biology, biochemistry and Bioinformatics
Title of the Course	GENOMICS AND PROTEOMICS
Credits	2
Objective:	• 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. • To provide basic knowledge about sample preparation, mass spectrometry workflow, different chromatography technologies and quantitative proteomics.
Learning Outcomes	• Students should be able to acquire knowledge and understanding of the fundamentals of genomics and proteomics, transcriptomics and metabolomics. • Able to understand and appreciate the applications in various areas of

	biology/medical field	
Contents:	**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.	15 hrs
	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 hrs
Pedagogy	Lectures, tutorials, assignments	
References/ Readings	1. Ann Batiza (2005) Bioinformatics, genomics, and proteomics: getting the big picture.. Infobase Publishing, 2. Benjamin Cummings (2007)vBioinformatics, 2nd Edition. 3. Glick BR & Pasternak JJ, (1998) Molecular Biotechnology, 3rd Edition, ASM Press, 4. Kobe B., Gussand M. Huber T. Campbell A.M &Heyer L.J (2008)- Structural Proteomics: High-Throughput Methods (Methods in Molecular Biology) Discovering Genomics, Proteomics and	

	5. Liebler, D.C. (2002), Introduction of Prteomics: Tools for the new Biology. Totowa, NJ: Humana Press. 6. Suhai Sc(2000) Genomics and proteomics: functional and computational aspects Springer.

Course Code:	MBTG-505	
Title of the Course	Solid Waste Management	
Credits	3	
Objective:	• To develop required skills in Plan segregation, collection, transportation, recycling and disposal of municipal solid waste • 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. • Provide relevant information about municipal solid waste reduction and on hazardous waste management.	
Learning Outcomes	At the end of this course, the students will be able to: • explain solid waste management systems with respect to its physical properties, and associated critical considerations in view of emerging technologies. • outline sources, types and composition of solid waste with methods of handling, sampling and storage of solid waste. • select the appropriate method for solid waste collection, transportation, redistribution, disposal and treatment. • describe methods of disposal of hazardous solid waste.	
Contents:	**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 omaterials recovered from MSW.	15 hours
	MODULE II • Handling, Separation and Storage of Solid Waste: -Handling and separation of solid waste at site. Material separation by pick in, screens, float and separator magnets and electromechanical separator and other latest devices for material separation. -Waste handling and separation at Commercial and industrial facilities. -Storage of solid waste at the sources. • Processing of Solid Waste: -Processing of solid waste at residence e.g. Storage, conveying, compacting, Shredding, pulping, granulating etc. -Processing of solid waste at Commercial and industrial site.	15 hours
	Module III	

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	• 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. -Bio-medical waste, its sources, generation, storage, transportation and Disposal. • Solid waste management and sustainable development: Case studies	15 hrs
Pedagogy	Lectures, tutorials, case studies, assignments	
References/ Readings	1) Chaterjee, A K, (2000), Introduction to environmental biotechnology. PHI, India. 2) Colin, M. (2012). Marine Microbiology: Ecology and applications. Second edition. Garland science. 3) Satyanarayana, T., Johri, B. and Anil, T., (2012). Microorganisms in Environmental Management, Springer Publishers. . 4) Kennish, M. J. (2019). Practical Handbook of Estuarine and Marine Pollution. CRC Press, Francis and Taylor. 5) King, R. B., Sheldon, J. K. and Long, G. M. (1998). Practical Environmental Bioremediation: The Field Guide, Lewis Publishers. 6) Meena, S.M and Naik, M.M. (2019). Advances in Biological Science Research: a practical approach. Elsevier. 7) Prabhu, M. (2016). Resource recovery from wastewaters for sustainable development. shodhganga.inflibnet.ac.in http://hdl.handle.net/10603/84904.	

SEMESTER IV

Course Code:	MBTR-509	
Title of the Course	RESEARCH METHODOLOGY	
Credits	2	
Objective:	The aim of this course is 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. • The course will give the student an overview of research methods.	
Learning Outcomes	At the end of this course, • students will be able to understand basic elements of scientific research including research methods, research planning, writing research proposal, data collection and analysis and writing scientific communications.	
Contents:	• **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 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	15 hrs

	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 hrs
Pedagogy	Lectures, tutorials, assignments	
References/ Readings	1. Alley, M., (1996). The Craft of Scientific Writing, Springer Science and Business Media. 2. Barbara Gastel and Day R.A. (2016). How to write and publish a scientific paper. Greenwood. 3. Cooray P.G. (1992). Guide to Scientific and Technical Writing. P.G. Cooray, Hindagala, Sri9 Lanka, 4. Kothari C. R., (2004). Research Methodology Methods and Techniques, New Age International. 5. Kumar, R. C., (2008). Research Methodology. APH Publ Corporation, New Delhi. . 6. Shamoo, A. E. and Rasnik D. B. (2015). Responsible conduct of research. Oxford University Press, New York.	

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Course Code:	MBTR-510
Prerequisite	MBTC-407,MBTC 408, MBTR-501 (ANY TWO)
Title of the Course	SYNTHETIC BIOLOGY
Credits	2
Objective:	The objective of course is to • redesign organisms for useful purposes by engineering them to have new abilities.

	• harness the power of nature to solve problems in medicine, manufacturing and agriculture.	
Learning Outcomes	The students will be able to understand • apply the concepts of synthetic biology for the design of biological systems. • How the limits of existing technology be overcome by DNA synthesis technology • And identify the biological problems that have limitations for industrial use and to analyze how synthetic biology can be applied as a solution.	
Contents:	**Module I** • Synthetic biology: Introduction., History , Top down and Bottom up approach. • Enabling technologies • Emerging tools for DNA synthesis • Artificial DNA synthesis, • Synthetic genomics • Genome modularity concepts,: Biobricks , Assembly method: 3 Antibiotic (3A) Assembly, Amplified Insert Assembly, Gibson Scarless Assembly, Methylase-assisted (4R/2M) Assembly • Golden gate cloning • Synthetic biological circuits: oscillators, bistable switches, logical operators, analog tuners • Circuit design • Modeling • Microfluidics • Synthetic transcription factors	15 hrs
	Module II • Genome editing: CRISPR technologies, gene therapy, synthetic immunology • Artificial cells Synthetic genomics, *Mycoplasma laboratorium*, Protocell • Computational method for protein engineering, pathway engineering, circuit designs using biological parts for creating synthetic biological constructs and strain design • Xenobiology using nucleic acid analogues, xenonucleic acids, unnatural base pairs and expanded genetic code • Applications of synthetic biology in biosensors, biological computers, organoids, bio-printed organs, space explorations. • Ethics on creation of life and ethical support for synthetic biology	15 hrs
Pedagogy	Lectures, tutorials, assignments	
References/ Readings	1. Andrea M M (2018) Introduction to Synthetic Biology Springer Verlag 2. Covert M. W.(2018) Fundamentals Of Systems Biology From Synthetic Circuits To Whole-Cell Models Taylor & Francis 3. Davies J. A (2018) Synthetic Biology: A Very Short Introduction Oxford	

	4. Kaebnick G. E. , Murray T. H. , Lustig A ,Boldt J (2013) Synthetic Biology and Morality Artificial Life and the Bounds of Nature MIT Press Ltd 5. Marchisio, M.A (2021) Computational Methods in Synthetic Biology Springer 6. Singh V., Dhar P.K. (2015) Systems and Synthetic Biology. Springer

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Course Code:	MBTR-511	
Prerequisite	MBTC 408, MBTC 407, MBPC 409 (Any two)	
Title of the Course	PLANT AND ANIMAL BIOTECHNOLOGY	
Prequisite	MBTC-407, MBTC-408, MBPC 409 (ANY TWO)	
Credits	2	
Objective:	The course is designed to provide a • comprehensive exposure to advances in animal and plant biotechnology. • Student is expected to have a clear understanding of basic biotechnology techniques to learn recent advances in the field	
Learning Outcomes	• Students will learn to combine previously acquired knowledge of biotechnology to understand the advance application in human welfare.	
Contents:	**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 live stock, Ethics of cloning Disease resistant transgenics, animal models for disease study, • Pharming, improving milk quality, improving traits, Xenografts, Toxicological applications, knock outs	15 hrs
	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;	15 hrs

	• Post-harvest bioengineering; Plant architecture; Flowering behavior • Plants as Biofactories Concept of biofactories; Fermentation and production of industrial enzymes, vitamins and antibiotics and other biomolecules; • Cell cultures for secondary metabolite production; Production of pharmaceutically important compounds; Bioenergy generation	
Pedagogy	Lectures, tutorials, assignments	
References/Readings	1. Bongso A. and Lee E.H .(2004) Stem cells from bench to bed side World Scientific publisher 2. Denis M., (2007), Plant Breeding and Biotechnology: Societal Context and the Future of Agriculture,Cambridge University Press, 3. Gupta P. K. 2015. Plant Biotechnology. Rastogi Publication. 4. Jordan B.R,(2006) The Molecular Biology and Biotechnology of Flowering, CABI Publication 5. Neil W., (2007) Phytoremediation: Methods and Reviews, Humana Press,. 6. Singh B. D. 2015. Plant Biotechnology. Kalyani Publisher. 7. Slater A., Scott N., and Fowler ., (2003), Plant Biotechnology: The genetic manipulation of plants. Oxford University Press,	

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Course Code:	MBSR-501	
Prerequisite	Students must know to swim 200 meters (any style) and be able to float 10 minutes	
Title of the Course	SCUBA DIVING	
Credits	2	
Objective:	Skill-based course with an objective to • Familiarize divers with knowledge, procedures, techniques, and problems of underwater diving. • Appreciate and preserve marine life .	
Learning Outcomes	• Will be able to do underwater surveying. • Collection of underwater marine samples • Able to enrol for advanced scuba diving course	
Contents:	**Module I** Dive Theory • Introduction • Diving equipment • Physics • Physiology • Planning dives • Executing dives	15 hrs

	• The underwater world • Scuba experience and beyond	
	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 hrs
Pedagogy	Lectures, tutorials, practical onsite training	
References/Readings	1) PADI (2015) PADI Open Water Diver Manual PADI publisher 2) Graver, D. (2016) Scuba Diving. Human Kinetics Publishers 3) Cole, S. and Brandon M. (2013) Reef Life: A Guide to Tropical Marine Life Firefly Books Ltd	

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Annexure III

School of Biological Sciences and Biotechnology
Ph.D. Biotechnology program
Research Methodology

Title of the Course	RESEARCH METHODOLOGY	
Credits	4	
Objective:	This course aims to • Develop required skills in the research scholars to acquire the following competency: Plan research, write research proposals, carry out data collection and analysis and write scientific communication. • Give the student an overview of research methods.	
Learning Outcomes	At the end of this course, • students will be able to understand the basic elements of scientific research, including research methods, planning, writing the research proposal, data collection/analysis and writing scientific communications.	
Contents:	**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 the scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process. • Problem Identification and Experimental Design– Research Question – Investigation Question –Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance. • 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 uses, Descriptive Research Designs – Concept, types and uses. Experimental Design: Concept of Independent & Dependent variables. • Project proposal writing, Tools for literature survey, Defining the aims and objectives, Work Plan – Time-bound Frame. • 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 the size of the sample-Practical considerations in sampling and sample size.	15 hrs

	• 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 the testing hypothesis of association. SPSS software	
	MODULE II • Importance of communicating research, Ethical aspects in academic writing, Plagiarism, and software to detect it. • Types of scientific writing and Research manuscript writing: reports, short communication, manuscript/original articles, review articles, thesis writing. • Fundamentals of a scientific paper: Drafting titles and abstracts, Authorship, Keywords, Introduction, Material and methods, Results and Discussion, Conclusion, Acknowledgement, Conflicts of Interest, Scientific Objectivity, and Bibliography. • Journal selection for publication, Tools for suggesting research journals, Open access, predatory journals, and 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 hrs
	Module III • Measures of Central Tendency and dispersion: mean, median, mode, range, standard deviation, variance, coefficient of variation, skewness, kurtosis • Probability analysis: axiomatic definition, axioms of probability: addition theorem, multiplication rule, conditional probability, and applications in biology. • Bernoulli trials, Binomial distribution and its applications, Poisson distribution, Normal distribution, z, t, test, levels of significance • Testing of hypotheses: null and alternative hypotheses, Type I and Type II errors • Correlation, Simple linear regression, multiple regression and principal component analysis. • Analysis of variance. • Patents and Copyrights and its relevance to research • Bioinformatics databases. BLAST and Multiple sequence alignment for phylogenetic analysis. • NGS sequencing methodology and assembly of raw sequence to contigs. Metagenomic DNA isolation and sequencing.	15 hrs
	Module IV • Scanning-tunneling Microscopy, Scanning electron microscopy, Transmission electron microscopy, Cryo-	

	electron microscopy, Atomic force Microscopy, Fluorescence microscopy, Confocal Microscopy • Nuclear magnetic resonance Spectroscopy. Electron spin resonance spectroscopy, MS, FTIR, MALDI-TOF, XRD, Raman spectroscopy, AAS • Principle, methodology and interpretation of results: Gel filtration, Ion exchange, Hydrophobic column chromatography, GC, HPLC. • Flow cytometry, Real-time PCR.	15 hrs
Pedagogy	Lectures, tutorials, assignments	
References/Readings	1. Kothari C. R., (2004) Research Methodology Methods and Techniques, New Age International. 2. Kumar, R. C., (2008) Research Methodology. APH Publ Corporation, New Delhi. 4. Barbara Gastel and Day R.A. (2016) How to write and publish a scientific paper. Greenwood. 5. Alley, M., (1996) The Craft of Scientific Writing, Springer Science and Business Media. 6. Cooray P.G. (1992). Guide to Scientific and Technical Writing. Hindagala, 7. Shamoo, A. E. and Rasnik D. B. (2015) Responsible conduct of research. Oxford University Press, New York. .	

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