RAMAIAH
Institute of Technology

CURRICULUM

for the Academic year 2022 – 2023

(Batch: 2022-2024)

DEPARTMENT OF BIOTECHNOLOGY

I-IV
M.Tech. Biotechnology

RAMAIAH INSTITUTE OF TECHNOLOGY
(Autonomous Institute, Affiliated to VTU)
BANGALORE – 54

About the Institute

Dr. M. S. Ramaiah a philanthropist, founded 'Gokula Education Foundation' in 1962 with the objective of serving society. M S Ramaiah Institute of Technology (MSRIT) was established under the aegis of this foundation in the same year, creating a landmark in technical education in India. MSRIT offers 17 UG programs and 15 PG programs. All these programs are approved by AICTE. All eligible UG and PG programs are accredited by National Board of Accreditation (NBA). The institute is accredited with **'A^{+}' grade by NAAC in March 2021** for 5 years. University Grants Commission (UGC) & Visvesvaraya Technological University (VTU) have conferred Autonomous Status to MSRIT for both UG and PG Programs since 2007. The institute is also been conferred autonomous status for Ph.D program since 2021. The institute is a participant to the Technical Education Quality Improvement Program (TEQIP), an initiative of the Government of India. The institute has 380 competent faculty out of which 65% are doctorates. Some of the distinguished features of MSRIT are: State of the art laboratories, individual computing facility for all faculty members, all research departments active with sponsored funded projects and more than 300 scholars pursuing Ph.D. To promote research culture, the institute has established Centre of Excellence for Imaging Technologies, Centre for Advanced Materials Technology, Centre for Antennas and Radio Frequency systems (CARFS), Center for Cyber Physical Systems, Schneider Centre of Excellence & Centre for Bio and Energy Materials Innovation.**M S Ramaiah Institute of Technology has obtained "Scimago Institutions Rankings" All India Rank 107 & world ranking 600 for the year 2022.**

The Entrepreneurship Development Cell (EDC) and Section 8 company "Ramaiah Evolute" have been set up on campus to incubate startups.**M S Ramaiah Institute of Technology is recognized by Atal Ranking of Institutions on Innovation Achievements (ARIIA), MoE, Govt. of India.** MSRIT has a strong Placement and Training department with a committed team, a good Mentoring/Proctorial system, a fully equipped Sports department, large air-conditioned library with good collection of book volumes and subscription to International and National Journals. The Digital Library subscribes to online e-journals from Elsevier Science Direct, IEEE, Taylor & Francis, Springer Link, etc. MSRIT is a member of DELNET, CMTI and VTU E-Library Consortium. MSRIT has a modern auditorium and several hi-tech conference halls with video conferencing facilities. The institute has excellent hostel facilities for boys and girls. MSRIT Alumni have distinguished themselves by occupying high positions in India and abroad and are in touch with the institute through an active Alumni Association. **As per the National Institutional Ranking Framework (NIRF), MoE, Government of India, M S Ramaiah Institute of Technology has achieved 67th rank among 1249 top Engineering Institutions & 17th Rank for School of Architecture in India for the year 2022 and is 1st amongst the Engineering Colleges affiliated to VTU, Karnataka.**

About the Department

The Department of Biotechnology established in 2002 offers a four year B.E. Biotechnology Program with an intake of 60 students and a two-year M.Tech. Biotechnology Program with an intake of 18 students. The UG and PG curriculum emphasizes on biology-engineering interface bringing together engineering principles and life sciences to impart knowledge in core areas of Biotechnology. Both UG and PG Programs are accredited by the National Board of Accreditation (NBA). The Department is a recognized Research Centre by VTU, Belgaum, offering M.Sc (Engg.) by research and PhD programs. The Department also offers a Post Graduate Diploma in Biopharmaceutical Technology under the Biotechnology Skill Enhancement Programme (BiSEP), supported by the Department of IT & BT, Government of Karnataka.

The Department has 15 faculty members all of them are PhD holders. The faculty members have competence in core areas of Biotechnology viz. Food and Agricultural Biotechnology; Health and Medical Biotechnology; Environmental Biotechnology and Bioprocess Engineering. The faculty members have expertise in diverse disciplines of Biotechnology with focused research funded by national/state funding agencies (DST, AICTE, KBITS, VGST, VTU, RGUHS etc.). The average number of publications of the department in SCI and SCOPUS-indexed journals is 30/per year. The Department has collaborations with some of the leading biotech industries like Biocon, Hindustan Unilever Limited (HUL), Bristol Myers Squibb India Ltd, Novozymes South Asia Pvt Ltd, Merck Life Sciences, Himalaya Drug Company, etc.

The Department has well-equipped academic laboratories and state-of-the-art research laboratories. High-quality research-based in-house projects guided by the faculty have attracted state funding, resulting in publications in high-impact journals, and won Best project awards at the state level. Students carry out their internships at various premier institutes in India and abroad. Several students receive the prestigious Indian Science Academies Fellowship (INSA) and Jawaharlal Nehru Centre for Advanced Scientific Research (JNCSAR) Summer research fellowship. Every year, a sizeable number of graduate students pursue their higher education at various premier Institutes in India and abroad after qualifying for the GATE, GRE & TOEFL exams. The Department has established student clubs and professional student chapters to provide a collaborative learning platform for the students. Students at the Department of Biotechnology not only excel in academics but also have received awards and recognitions in various extra-curricular activities.

VISION OF THE INSTITUTE

To be an Institution of International Eminence, renowned for imparting quality technical education, cutting edge research and innovation to meet global socio-economic needs.

MISSION OF THE INSTITUTE

RIT shall meet the global socio-economic needs through

- Imparting quality technical education by nurturing a conducive learning environment through continuous improvement and customization.
- Establishing research clusters in emerging areas in collaboration with globally reputed organizations.
- Establishing innovative skills development, techno-entrepreneurial activities and consultancy for socio-economic needs.

QUALITY POLICY

We at Ramaiah Institute of Technology strive to deliver comprehensive, continually enhanced, global quality technical and management education through an established Quality Management System complemented by the synergistic interaction of the stakeholders concerned

VISION OF THE DEPARTMENT

To be a leading Biotechnology Engineering department that imparts quality technical education with strong research component, to develop solutions in the field of food, health and environment.

MISSION OF THE DEPARTMENT

To provide quality technical education in a conducive learning environment to produce professionals, researchers with a zeal for lifelong learning and a commitment to society.

Programme Educational Objectives (PEOs) of the program

PEO 1: To produce postgraduates who can articulate technical developments in the field of biotechnology and apply relevant tools to solve problems in real life situations

PEO 2: To enable postgraduates to have an ability to design and conduct research to meet desired needs within realistic economic, environmental, socio-political, ethical, health, safety & sustainability realms

PEO 3: To prepare postgraduates to be successful professionals in industry, academia, research, entrepreneurial pursuit and consulting firms

PEO 4: To prepare students to enrich their knowledge & skills throughout their career

Programme Outcomes (POs)

PO1: An ability to independently carry out research/investigation & development work to solve practical problem

PO 2: An ability to write & present a substantial technical report/document

PO 3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the programme. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO 4: Demonstrate the ability to design, conduct experiments and analyze data in the field of Biotechnology

PO 5: Able to employ Biotechnology tools in biological research

Scheme Structure of MTech Programme from Academic year 2022-2023

Semester	Professional core course-Theory (PCC)	Professional core course-Lab (PCCL)	Professional Elective Course (PEC)	Mandatory Credit Course (MCC)	Project Work/Seminar (PW)	Internship (INT)	Total Semester Credits
First	6	2	11	3	-	-	22
Second	8	2	12	-	-	-	22
Third	4	-	4	-	4	4	16
Fourth	-	-	-	-	20	-	20
Total	18	4	27	3	24	4	80

MTech in Biotechnology
Scheme of Teaching and Examination: 2022-2023

I SEMESTER							
Course code	**Course**	**Teaching department**	**Category**	**Credits**			
				L	**T**	**P**	**Total**
MBT11	Bioseparations & Bioanalytical Techniques	BT	PCC	2	1	0	3
MBT12	Advanced Molecular Biology and Genetic Engineering	BT	PCC	3	0	0	3
MBTE13X	Professional Elective Course-1	BT	PEC	3	0	0	3
MBTE14X	Professional Elective Course-2	BT	PEC	4	0	0	4
MBTE15X	Professional Elective Course-3	BT	PEC	4	0	0	4
RMI16	Research Methodology and IPR	BT	MCC	3	0	0	3
MBTL17	Advanced Molecular Biology and Genetic Engineering Lab	BT	PCCL	0	0	1	1
MBTL18	Bioseparations & Bioanalytical Techniques Lab	BT	PCCL	0	0	1	1
			Total	**19**	**1**	**2**	**22**

II Semester							
Course code	**Course**	**Teaching department**	**Category**	**Credits**			
				L	**T**	**P**	**Total**
MBT21	Industrial Biotechnology	BT	PCC	3	1	0	4
MBT22	Biopharmaceutical Technology	BT	PCC	4	0	0	4
MBTE23X	Professional Elective Course-4	BT	PEC	4	0	0	4
MBTE24X	Professional Elective Course-5	BT	PEC	4	0	0	4
MBTE25X	Professional Elective Course-6	BT	PEC	4	0	0	4
MBTL26	Biopharmaceutical Technology Lab	BT	PCCL	0	0	1	1
MBTL27	Industrial Biotechnology Lab	BT	PCCL	0	0	1	1
				19	**1**	**2**	**22**

III Semester							
Course code	**Course**	**Teaching department**	**Category**	**Credits**			
				L	**T**	**P**	**Total**
MBT31	Multi-Omic Technologies	BT	PCC	3	1	0	4
MBTE32X	Professional Elective Course-7	BT	PEC	4	0	0	4
MBTI33	Internship	BT	INT	0	0	4	4
MBT34	Project Work-I	BT	PW	0	0	4	4
			Total	**7**	**1**	**8**	**16**

IV Semester							
Course code	**Course**	**Teaching department**	**Category**	**Credits**			
				L	**T**	**P**	**Total**
MBTP41	Project Work-II	BT	PW	0	0	20	20
			Total	**0**	**0**	**20**	**20**

Professional Elective Courses

Elective	**1**	**2**	**3**	**Credits**			
				L	**T**	**P**	**Total**
MBTE13X	Food Process Engineering	Bioprocess Modelling & Simulation	Current Trends in Drug Discovery & Research	3	0	0	3
MBTE14X	Biomaterials and Medical Diagnostics	Environmental Biotechnology	Protein Engineering	4	0	0	4
MBTE15X	Experimental Design and Analysis	Bioreactor Technology	Advanced Cell culture & Animal Biotechnology	4	0	0	4
MBTE23X	Forensic Science and Toxicology	Bioprocess Engineering	Immunology & Immunotechnology	4	0	0	4
MBTE24X	Biotechnology Entrepreneurship	Bioenergy and Biofuels Technology	Stem Cell Technology & Regenerative Medicine	4	0	0	4
MBTE25X	QA, QC & Regulatory affairs	Metabolic Engineering	Advanced Cancer Biology	4	0	0	4
MBTE32X	Nanobiotechnology	AI Applications in Biotechnology	Infectious Diseases	4	0	0	4

Where X= 1, 2 & 3; L-Lecture, T-Tutorial, P-Practical

BIOSEPARATION AND BIOANALYTICAL TECHNIQUES

Course Code: MBT11 **Credits:** 2:1:0

Contact Hours: 28+14

Course Coordinators: Dr. Ahalya N and Dr. Dhamodhar P

UNIT-I

Cell Disruption and Fractionation

Intracellular products, Cell wall, Cell disruption -Physical, chemical, mechanical and Enzymatic Methods. Proteins of inclusion bodies. Hydrophobic interaction chromatography; Reverse phase chromatography. Basic theory of retention in RPC and HIC.

Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
Link: https://onlinecourses.nptel.ac.in/noc20_bt25/preview

UNIT-II

Separation Techniques and Product Polishing Techniques

Capillary electrophoresis, 2D- Gel Electrophoresis, Isoelectric Focusing; Isotachophoresis. Centrifugation- Preparative centrifugation, Analytical Ultracentrifugation, Flow cytometry- Fluorescence-activated cell sorting (FACs) and its applications. Product polishing techniques: Crystallization; Drying. Case studies; product formulation and additives, freeze-drying process.

Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
Link: https://onlinecourses.nptel.ac.in/noc20_bt25/preview

UNIT-III

Spectroscopic Techniques-I

Nature of Electromagnetic radiation, Electromagnetic spectrum; Atomic energy levels, Molecular electronic energy levels- Translational, Vibrational, Rotational Electronic states; Principle and applications of Infrared Spectroscopy, Principle and Applications of Spectrofluorimetry, UV-visible spectroscopy in biomolecular analysis. Fluorescence, Quenching, Quantum yield, Chromophore, Fluorophore, Principle, technique, and applications of Fluorescence Resonance Energy Transfer (FRET) in biological systems.

Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
Link: https://nptel.ac.in/courses/102103044
https://www.youtube.com/watch?v=SkFl79Q3A48

UNIT-IV

Spectroscopic Techniques II

Polarization of light, Plane polarized vs Circularly polarized light, Optical rotation; Circular Dichroism, Principle and applications of CD for structural analysis. Principle and applications of Dynamic Light Scattering (DLS), Mass spectrometry- Ionization methods-EI, ESI, DI, MALDI; Instrumentation and quantitation of spectrum.

Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
Link: https://nptel.ac.in/courses/102103044
https://www.youtube.com/watch?v=SkFl79Q3A48

UNIT-V

Advanced Structural Studies of Biomolecules

NMR spectroscopy, nuclear spin states, electronic spin behaviour. Chemical shift & Shielding, Nuclear Magnetic Spectrometer, NMR- 1-D, 2-D, Nuclear Overhauser effect (NOE), COSY, NOESY. Structure, Function/applications of Green Fluorescent Protein (GFP) and Proteasome complex. Principle of Surface Plasmon Resonance (SPR) and its applications.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Link: https://nptel.ac.in/courses/102103044
https://www.youtube.com/watch?v=SkFl79Q3A48

Textbooks:

1. Harrison, R.G., Todd, P., Rudge, S.R., and Petrides, D.P. (2015). Bioseparations
2. Belter PA, Cussler EL and Wei-Shou Hu (2001) Bioseparations-Downstream Processing for Biotechnology, Wiley-Interscience Publication.
3. Keith Wilson & John Walker (2010), 7th Edition, Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press.
4. Douglas A. Skoog, F. James Holler, Stanley R. Crouch (2006), Principles of Instrumental Analysis, Cengage Learning.

Reference Books:

1. Donald L. Pavia, Gary M. Lampman, George S. Kriz and James A. Vyvyan (2008), Spectroscopy, Cengage Learning.
2. Cantor CR and Schimmel PR (1980) Biophysical Chemistry: Part I, The conformation of biological macromolecules.

3. Kensal Edward Van Holde, W. Curtis Johnson, PuiShing Ho (2006), Principles of Physical Biochemistry. PeasrsonPrintice Hall.

Web links and Video Lectures:

Bioanalytical Techniques

1. https://nptel.ac.in/courses/102103044
2. https://www.youtube.com/watch?v=SkFl79Q3A48

Bioseparation Processes

1. https://onlinecourses.nptel.ac.in/noc20_bt25/preview

Course Outcomes (COs):

At the end of the course, Students will have the ability to:

1. Disrupt the cell and purify the biomolecules using chromatographic techniques (PO1 & PO4)
2. Apply the Separation and product polishing techniques. (PO3)
3. Understand various spectroscopic techniques for the analysis of biomolecules. (PO4 & PO5)
4. Apply spectroscopic techniques for studying the properties of molecules. (PO4 & PO5)
5. Study and interpret the spectra of biomolecules. (PO1 & PO5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 & CO2
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
Tutorial Test	10	CO1, CO2, CO3, CO4 & CO5
Semester-End Examination:	100	CO1, CO2, CO3, CO4 & CO5

ADVANCED MOLECULAR BIOLOGY AND GENETIC ENGINEERING

Course Code: MBT12 **Credits:** 3:0:0

Contact hours: 42L

Course Coordinator(s): Dr. Ravikumar Y. S. and Dr. Abhijith S. R.

UNIT-I

Molecular Cell Biology: Cell junction

Cell-cell adhesion, cadherins, CAMS (NCAMS), selectins, integrins, desmosomes, hemidesmosomes, tight junction, gap junction, Cytoskeleton: Tubulins, intermediate filaments, and actins. **Cell Signaling:** Principles of cell communication, cell signaling via G-protein coupled receptors, Enzyme coupled receptors and membrane channels. Small intracellular signaling molecule. **Cell cycle:** events of cell cycle check the regulation of cell cycle. **Protein trafficking:** transport through nuclear envelope, mitochondrial membrane and ER membrane.

Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint Presentation.
Links: Molecular cell biology https://archive.nptel.ac.in/courses/102/106/102106025/

UNIT-II

Replication and Transcription:

Replication and Transcription: Prokaryotic DNA replication; Central dogma discovery of mRNA, semi discontinues replication. Origin of replication, Role of polymerse, toposimerases ARS. G_1 licensing, Regulated of replication, significance of telomerase. DNA repair. **Transcription and RNA processing:** Promoters and σ-factors interaction. Eukaryotic promoters and role of transcription factors. RNA Processing: importance of RNA capping and polyadenylation , Spliceosome Machinery, Splicing Pathways, Alternative splicing, ADAR and CDAR. rRNA and tRNAs processing,

Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint Presentation
Links: Mechanism of replication:https://nptel.ac.in/courses/102108086
Mechanism of transcription:https://nptel.ac.in/courses/102108086

UNIT-III

Translation, regulation of gene expression:

Protein Synthesis and gene expression regulation: Prokaryotic and Eukaryotic mRNA. Prokaryotic translation factors, role of EF-Tu in translation elongation. Mechanism of Peptide Bond Formation, RIBOSOME RECYCLING, Eukaryotic translation: Scanning Model, 43S PIC. mRNA preparation, IRES mediated translation

initation Deciphering genetic code. Post translational modification. **Regulation of prokaryotic genes expression:** Operons and their types, role of sigma factors in Regulation of Gene expression. **Regulation of eukaryotic gene expression: Enhancer, Activators and Repressors,** Histone modification and Chromosome remodeling**:** RNA intereference, siRNAs, miRNAs, protein degradation and turnover

Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint Presentation
Links: Mechanism of gene expression and regulation*:*
https://nptel.ac.in/courses/102108086

UNIT-IV

Introduction to recombinant technology

Principles of gene Manipulation: Isolation of DNA, Enzymes, Prokaryotic and Eukaryotic Vectors, Cloning a Specific Gene. Gene transfer methods. Screening recombinants, Protein Expression and purification. Expression Systems, Fusion Proteins. Site-Directed Mutagenesis.

Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint Presentation
Links: DNA isolation and enzymes of rDNA technology
https://nptel.ac.in/courses/102103074
cDNA and Genomic DNA library construction and screening:
https://nptel.ac.in/courses/102103074 and https://nptel.ac.in/courses/102103013

UNIT-V

Cloning strategies

Application of gene cloning: Products by Recombinant Microorganisms, Production of recombinant proteins from eukaryotic expression system. Production and Applications of Transgenic Plants and animals. Gene Therapy: Gene silencing by RNA interference technology- Genome editing technology: Mechanism and applications of Zinc Finger Nucleases, TALENS, and CRISPR/Cas.

Pedagogy/Course delivery tools: Chalk and Talk, Power Point Presentation
Links: Genome Editing and Engineering https://nptel.ac.in/courses/102103093

Textbooks:

1. Watson JD. - Molecular Biology of the Gene, Pearson Education, 2014.
2. Robert F. Weaver - Molecular Biology Edition, McGraw-Hill, 3rd 2003.
3. Brown T.A - Gene cloning and DNA analysis: an introduction, Wiley Blackwell 6th ed. 2010.

Reference book:

1. Maniatis T, Fritsch E.F. & Sambrook J. - Molecular Cloning: A Laboratory Manual. CSHL, 3rd edition, 2002.
2. Old W. & Primrose; Principles of Gene Manipulation. S.B. University Press, 6th edition, 2001.
3. Lewin B - Genes IX, Jones, and Bartlett Publishers, 9th edition 2007.

Course Outcomes: On completion of this course students will able to:

1. Describe the organization of cytoskeleton molecular mechanisms for cell growth and cycle, and interactions of the cell with its environment. (PO3)
2. Acquire knowledge of eukaryotic genome replication and fidelity, and compare and analyze the mechanism of prokaryotic and eukaryotic transcription and RNA processing. (PO1,PO3 & PO4)
3. Describe the mechanism of translation and regulation of gene expression. (PO3 & PO4)
4. Select appropriate genetic engineering techniques for gene manipulation, (PO1, PO4 & PO5)
5. Distinguish genetic engineering techniques used to manipulate a prokaryotic and eukaryotic cell and describe genome editing technology and its application. (PO1,PO3)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 & CO2
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Quiz/Surprise test	10	CO1, CO2 & CO3
Assignment/Presentation	10	CO4 & CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4, CO5

RESEARCH METHODOLOGY & IPR

Course Code: RMI16 **Credits:** 3:0:0

Contact Hours: 42L

Course Coordinators: Nil

UNIT-I

Research Methodology: Introduction, meaning of research, Objectives of research, Motivation in research, Types of research, Research approaches, Significance of research, Research methods versus methodology, Research and scientific method, Importance of knowing how research is done, Research process, Criteria of good research, Problems encountered by researchers in India.

Defining the Research Problem: What is research problem, Selecting the problem, Necessity of defining the problem, the Technique involved in defining a problem, An illustration.

UNIT-II

Literature review: Primary and secondary sources, Reviews, Monograph, Patents, Research databases, Web as a source, Searching the web, Critical literature review, Identifying gap areas from literature and research database, Development of working hypothesis.

Research Design: Meaning of research design, Need for research design, Features of a good design, Importance concepts relating to research design, Different research designs, Basic principles of experimental design.

UNIT-III

Sampling Design- Census and sampling survey, Implications of a sample design, Steps in sampling design, Criteria of selecting a sampling procedure, Characteristics of a good sample design, Different types of sample designs, How to select a random sample, Random sample from an infinite universe, Complex random sampling designs.

Methods of Data Collection- Collection of primary data, Observation method, Interview method, Collection of data through questionnaires, Collection of data through schedules, Different between questionnaires and schedules, some other methods of data collection, Collection of secondary data, Selection of appropriate method for data collection, Case study method.

UNIT-IV

Multivariate Analysis: The nature of the multivariate analysis, Classifying multivariate techniques, Analysis of dependence, Analysis of interdependence.

Probability distributions: Introduction to Probability, Laws of Probability, Baye's theorem, Discrete and Continuous random variables, Binomial, Poisson distributions, Normal and Exponential distributions - Simple problems, applications

UNIT-V

Research Ethics and Intellectual Property: Ethics- Ethical issues, Ethical committees (human & animal), Research ethics; IPR- Intellectual property rights and Patent law, Commercialization, Copyright, Royalty, Trade-related aspects of intellectual property rights (TRIPS); Scholarly publishing- IMRAD concept and design of research paper, Citation and acknowledgement, Plagiarism, Reproducibility and Accountability.

Textbooks

1. Kothari CR and Garg G. 2019. Research Methodology: Methods and Techniques, Fourth Edition, New Age International Publishers, ISBN (13): 978-81-224-2488-1.
2. Panneerselvam R. 2013. Research Methodology, Second Edition, Prentice Hall India Learning Private Limited, ISBN (13): 978-8120349469.

Reference Books

1. Zikmund WG, Babin BJ, Carr JC and Griffin M. 2013. Business Research Methods, Ninth Edition, Cengage India Private Limited, ISBN (13): 978-9353503260.
2. Wadhera BL. 2010. Law Relating to Intellectual Property: Patent, Trademarks, Designs and Geographical Indication, Universal Law Publishing, ISBN: ISBN: 978-9350350300.

Course Outcomes

At the end of the course, the student will be able to

1. Understand the research methodology and define the problem for research.
2. Conduct a literature review and apply the principles of research design.
3. Apply the knowledge of various sampling procedures and different methods of data collection in the research.
4. Apply multi-variate techniques and concepts of probability distributions to real-time situations
5. Apply ethics and concepts of intellectual property in the research process.

ADVANCED MOLECULAR BIOLOGY AND GENETIC ENGINEERING LAB

Course Code: MBTL17 **Credits:** 0:0:1

Contact Hours: 14P

Course Coordinators: Dr. Prabha M and Dr. Roshni Ramachandran

List of Experiments

1. Cleavage of DNA by Restriction endonucleases and Analysis of DNA fragments for primer designing
2. Amplification of target DNA by Multiplex PCR and analysis by gel electrophoresis
3. SNP detection using PCR (kit method)
4. Gene expression analysis using RT PCR
5. Cloning: transfer a GFP gene into a plasmid vector and transformation into bacteria
6. Screening and calculation of transformation efficiency of gene-transformed cells
7. GMO detection using PCR (kit method)
8. Establishment of plant/animal cell culture
9. Protocols/SOPs for plant/Animal cell culture
10. Animal cell transfection and gene expression analysis
11. *Insilico* differential expression analyses of RNA-seq
12. *Insilico* retrieving gene information from TAIR database
13. Induction and expression of recombinant protein in cell
14. Detection of recombinant proteins by Western blotting

Any 12 experiments must be performed.

Textbooks:

1. Michael R. Green, Joseph Sambrook (2012). Molecular cloning: a laboratory manual. Volumes I -III.Cold Spring Harbor Laboratory Press, USA.
2. Brondyk, W. H. (2009). "Chapter 11 Selecting an Appropriate Method for Expressing a RecombinantProtein".*Methods in enzymology* 463: 131–147

Reference Books:

1. Brown T A. G. (2012) Genetics: A molecular approach, Garland Science, Taylor & Francis Group, New York, USA.
2. Sandy B. Primrose and Richard Twyman.(2006) Principles of Gene Manipulation and Genomics, Blackwell publishing.

3. Harris ELV and Angal S (1988) Protein Purification Methods, Ed. IRL Press at Oxford University Press.

Course Outcomes:

On completion of this course, a student will have improved ability to:

1. Standardize the protocol for detection, amplification, and quantification of DNA using PCR and primer design. (PO1, PO3, PO4 & PO5)
2. Apply the PCR techniques for the gene expression analysis (PO1, PO4 & PO5)
3. Establish plant or animal cell cultures and transfection of DNA. (PO3, PO4 & PO5)
4. Apply *insilico* analysis for gene expression and retrieving gene information (PO3, PO4 & PO5)
5. Analyze Animal cell transfection for gene cloning and recombinant protein production (PO3, PO4 & PO5)

Web links and Video Lectures (e-Resources):

1. http://mbvi-au.vlabs.ac.in/
2. https://mbvii-au.vlabs.ac.in/
3. https://www.labster.com/simulations/genetically-engineered-machine
4. https://dnalc.cshl.edu/view/17055-Virtual-Lab-Experiments-in-Biotechnology-DNA-Restriction-Analysis.html
5. https://bds-au.vlabs.ac.in/List%20of%20experiments.html
6. https://vlab.amrita.edu/index.php?sub=3&brch=273

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	20	CO1, CO2, CO3, CO4 & CO5
The internal test (20) and other components shall be taken for 30 marks.		
Other Components		
Record (continuous evaluation)	20	CO1, CO2, CO3, CO4 & CO5
Viva	10	CO1, CO2, CO3, CO4 & CO5
Semester-End Examination:	50	CO1, CO2, CO3, CO4 & CO5

BIOSEPARATIONS & BIOANALYTICAL TECHNIQUES LAB

Course Code: MBTL18 **Credits:** 0:0:1

Contact Hours: 14P

Course Coordinators: Dr Divyashri G & Dr Chandra Prabha M N

List of Experiments

1. Introduction to GLP guidelines about bioseparations and bioanalytical techniques.
2. Quantification of protein concentration using UV-VIS spectrophotometry.
3. Cell disruption by ultrasonication/homogenizer.
4. Optimization of protein enrichment operations: salting out and organic solvent precipitation.
5. Microwave-assisted extraction & kinetic studies of polymers (pectin) from plant material.
6. Preparation and characterization of pectin films using X-ray diffraction (XRD) and Thermal gravimetric analysis (TGA).
7. Analysis of Functional Groups in a given biomolecule using Infrared (IR) Spectroscopy of pectin.
8. Freeze-drying of protein/pectin solution.
9. Fraction of crude biomolecules: Flash Chromatography.
10. Characterization of crude biomolecules using Thin layer chromatography.
11. Method validation for determination of carbohydrates using High-Performance Liquid Chromatography.
12. Determination of polarity/partition coefficient of a biomolecule by an aqueous two-phase method.
13. Method validation for determination of amino acids using High-Performance Liquid Chromatography.
14. Immunotyping of Human PBMCs using CD - 45 Antibody (FITC).

Reference Books:

1. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2013). Fundamentals of analytical chemistry. Cengage learning.
2. Olivieri, A. C., Escandar, G. M., Goicoechea, H. C., & de la Peña, A. M. (2015). Fundamentals and analytical applications of multiway calibration. Elsevier.
3. Pearson, D. (1981). General methods in chemical analysis of foods pp: 11. Edinburgh/London/New York: Churchill Livingstone.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=kAiNq2HtBg8

2. https://www.youtube.com/watch?v=4j5cMHVPStc

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Design & optimization of ultrasonication process for cell disruption (PO-1,3,4,5)
2. Optimize protein enrichment operations (PO-4,5)
3. Prepare samples for characterization techniques (PO-1,4,5)
4. Validate the method amino acid and sugar analysis using HPLC (PO-2,3,4,5)
5. Interpretation of analytical technique results (HPLC, XRD, FT-IR and TGS results) (PO-3,4,5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test	20	CO1, CO2, CO3, CO4 & CO5
Other Components		
Lab assessment	20	CO1, CO2, CO3, CO4 & CO5
Record	10	CO1, CO2, CO3, CO4 & CO5
Semester-End Examination:	50	CO1, CO2, CO3, CO4 & CO5

INDUSTRIAL BIOTECHNOLOGY

Course Code: MBT21 **Credits:** 3:1:0

Contact Hours: 42L+14T

Course Coordinators: Dr. T P Krishna Murthy & Dr. Chandraprabha M N

UNIT-I

Development of Host Cells in Industrial Biotechnology

The Industrialization of Biology: Brief history of industrial biotechnology, the role of industrial revolution 1.0, 2.0, 3.0, 4.0, and 5.0 in the development of industrial bioprocess. Contribution of Industrial Biotechnology to UN Global Sustainable Development Goals. Cellular Systems for industrial bioprocess: Isolation, screening and improvement of industrially important host systems. Application of metabolic, protein/enzyme, and genetic engineering for improvement of industrial important cellular systems. Applications of mixed cultures, synthetic co-cultures/Synthetic microbial communities, and extremophiles in industrial biotechnology.

Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
Links:
https://www.ibiology.org/bioengineering/engineering-microbes/
https://www.ibiology.org/bioengineering/synthetic-biology/

UNIT-II

Media Formulation, Optimization and Sterilization

Typical media for industrial bioprocess, Media components and formulation, factors affecting the choice of media components. Media Optimization: Experimental strategies and model-based strategies, algorithmic approaches for media optimization. General consideration in the media preparation for animal cell culture bioprocessing. Sustainable biorefinery concept for industrial bioprocessing. Sterilization: Design of Batch and continuous sterilization, sterilization of fermenter/bioreactor, feeds, and liquid wastes. Sterilization by filtration.

Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
Links: https://nptel.ac.in/courses/102106053

UNIT-III

Bioprocess and Bioreactor Design

Modelling and kinetics of free and immobilized enzyme reactions. Stoichiometry and the kinetics of cell cultivation. Modelling of batch, fed-batch & continuous process

bioprocess systems. Design of bioreactor: Basic function of a bioreactor, aseptic operation and containment, bioreactor body construction, aeration and agitation, and oxygen transfer in a bioreactor. Sensors, Instrumentation, and Control of Bioreactors. Bioreactor for Liquid Systems: Reusable bioreactor systems, single-use technology, micro-bioreactors, gas phase bioreactors etc. Bioreactors for solid-state fermentation and wastewater treatment.

Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
Links: https://nptel.ac.in/courses/102106022

UNIT-IV

Development of Sustainable Industrial Bioprocess

Fermentation model, process model, inventory analysis, environmental impact assessment, and economic assessment of bioproducts/biopharmaceuticals production. Case studies: Ethanol, citric acid, Streptomycin, monoclonal antibodies, vaccines, nutraceuticals.

Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
Links: https://www.youtube.com/watch?v=5vjXCn26YlE

UNIT-V

Scale Up and Scale Down of Bioreactors and Industrial Bioprocess

General considerations in scale translation, process and equipment parameters affected by scale-up, scale translation for product development and process troubleshooting, scale-up effect on process variables, equipment, and cellular physiology, scale-up of equipment and geometrical similarity. scale up based on mechanical agitation and power consumption and mixing characteristics, the effect of scale on the physical behaviour of bioreactors, and scale up based on mixing time. Scale down in bioprocessing.

Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
Links: https://www.youtube.com/watch?v=dsCwSXN12Kc

Textbooks:

1. Moo-Young, M. (2019). Comprehensive Biotechnology, 3rd Edition, Elsevier.
2. Michael C. Flickinger (2013) Upstream & Downstream Industrial Biotechnology, John Wiley & Sons, Inc

3. Jagschies, G., Lindskog, E., Lacki, K., & Galliher, P. M. (Eds.). (2018). Biopharmaceutical Processing: Development, design, and implementation of manufacturing processes. Elsevier.

Reference Books:

1. Bajpai, P. (2019). Biotechnology in the chemical industry: Towards a green and sustainable future. Elsevier.
2. Okafor, N., & Okeke, B. C. (2017). Modern industrial microbiology and biotechnology. CRC Press.
3. El-Mansi, E. M. T., Nielsen, J., Mousdale, D., & Carlson, R. P. (Eds.). (2018). Fermentation microbiology and biotechnology. CRC press.
4. Lee, S. Y., Nielsen, J., & Stephanopoulos, G. (2016). Industrial biotechnology: products and processes. John Wiley & Sons.
5. Christoph Wittmann, James C. Liao. (2017). Industrial Biotechnology: Microorganisms. John Wiley & Sons.
6. Pau Loke Show, Chien Wei Ooi, Tau Chuan Ling (2019) Bioprocess Engineering: Downstream Processing, 1st Edition, CRC press.

Web links and Video Lectures (e-Resources):

1. Industrial Biotechnology: https://nptel.ac.in/courses/102/105/102105058/
2. Aspects of Biochemical Engineering: https://nptel.ac.in/courses/102/105/102105064/
3. Biochemical Engineering: https://nptel.ac.in/courses/103/105/103105054/
4. Industrial Biotechnology: https://www.coursera.org/learn/industrial-biotech
5. Industrial Biotechnology: https://www.edx.org/course/industrial-biotechnology-2
6. SuperPro Designer® : https://www.intelligen.com/training/videos/

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Appreciate the role of industrial revolutions and modern developments in the growth of bioprocess technology (PO3 & PO5)
2. Apply the principles of experimental design to optimize the design of suitable media for the industrial bioprocess (PO3, PO4 & PO5)
3. Understand and specify the suitable bioreactor configurations for industrial bioprocess (PO3, PO4 & PO5)
4. Analyze the process model for the bioproduction of various industrial chemicals and Asses the sustainability and environmental impact of the industrial bioprocess (PO3 & PO5)

5. Explore all aspects that affect the integrity of the bioprocess during the scale-up process (PO3,PO4 & PO5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1, CO2 &CO3
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
Quiz/Surprise Test/Tutorial Test	10	CO1, CO2, CO3, CO4 & CO5
Semester-End Examination:	100	CO1, CO2, CO3, CO4 & CO5

BIOPHARMACEUTICAL TECHNOLOGY

Course Code: MBT22 **Credits:** 4:0:0

Contact Hours: 56L

Course Coordinators: Dr.Lokesh K N

UNIT-I

Drug Development Process

Drug development process of protein-based therapeutics: Transforming New Molecular Entities into Drugs, Differences between Development of Biotechnology Products of Macromolecules and Chemical Products, Current Trends in Drug Development, Drug designing: Rational, combinatorial and High Throughput screening.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Links for topic: https://nptel.ac.in/courses/104106106

UNIT-II

Immunopharmacology

Immuno-pharmacology: Overview of immunopharmacology, Antibody-mediated response, Vaccines, Cell-mediated immune response, Cancer immunotherapy, Immunosuppressant, and immunostimulatory.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Links for topic: https://onlinecourses.nptel.ac.in/noc22_bt40/preview

Unit-III

Biotherapeutics

Biotherapeutics: Hematopoietic Growth Factors and Coagulation Factors, Interferons and Cytokines for Anti-infective and Cancer Therapy, Hormones, Enzymes, Antibodies, and Derivatives.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Links:

UNIT-IV

Nanotherapeutics

Nanotechnology for the delivery of proteins and nucleic acids-based therapeutics: Introduction to Nanotechnology in drug delivery, Nano-sized Advanced Delivery Systems as Parenteral formulation Strategies for Hydrophobic Anti-cancer Drugs, Engineering of Amphiphilic Block Copolymers for Drug and Gene Delivery, Nano-

emulsions for Intravenous Drug Delivery. Nanotechnology for Cancer Chemotherapy, Nanotechnology for Cancer Vaccine Delivery.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Links for topic:
https://archive.nptel.ac.in/content/storage2/courses/102105089/pdf/Mod%2011_Lecture%2055_Protein%20Nanoparticle%20Interactions.pdf

UNIT-V

Formulation and Biopharmaceutical Delivery Systems

Formulation of proteins and peptides: Making Small Protein Particles, Lyophilization, Multiphase Drug Delivery Systems, Protein Compaction, Self-Emulsifying Drug Delivery Systems, skin, and parental drug delivery system.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Links for topic: https://onlinecourses.nptel.ac.in/noc20_bt24/preview

Text Books:

1. Christine M. Bladon (2002) Pharmaceutical Chemistry, John Wiley & Sons, Ltd.
2. GrietjeMolema and Dirk KF. Meije (2002) Drug Targeting Organ-Specific Strategies r. Wiley-VCH.
3. Melgardt M. de Villiers (2007) Nanotechnology in Drug Delivery, Springer.

Reference Books:

1. Manfred E. Wolff (2000) Burger's Medicinal Chemistry and Drug Discovery (5th edition) A Wiley & Sons, Inc.
2. Rodney JY, Milo Gibaldi (2003) Biotechnology and Biopharmaceuticals transforming proteins and genes into drugs, A John Wiley & Sons, Inc., Publication.
3. Shayne cox gad (2007) Handbook of pharmaceutical Biotechnology A John Wiley & Sons, Inc., Publication.
4. GrietjeMolema and Dirk KF (2002) Drug Targeting Organ-Specific Strategies by Meijer. Wiley-VCH.
5. Gary Walsh (2003) Biopharmaceuticals Biochemistry and Biotechnology, Wiley.

Web links and Video Lectures (e-Resources):

1. https://onlinecourses.nptel.ac.in/noc22_bt40/preview
2. https://onlinecourses.nptel.ac.in/noc20_bt24/preview
3. https://nptel.ac.in/courses/104106106

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Comprehend the development, characterization, and evaluation of bio therapeutic proteins. (PO1 & PO5)
2. Applying the knowledge of immunology in the development of immunotherapeutics and diagnostics. (PO1 & PO3)
3. Explore the principles and applications of novel bio therapeutics (PO1, PO3 & PO5)
4. Apply the principles of nanotechnology in the research and development of nanomedicines. (PO1, PO3 &PO5)
5. Formulate protein-based drugs and study their physicochemical and pharmacological properties. (PO4 & PO5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 & CO2,
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components		
Assignment/Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
QuizTest	10	CO1, CO2, CO3, CO4 & CO5
Semester-End Examination:	100	CO1, CO2, CO3, CO4 & CO5

BIOPHARMACEUTICAL TECHNOLOGY LAB

Course Code: MBTL26 **Credits:** 0:0:1

Contact Hours: 14P

Course Coordinators: Dr. Roshni Ramachandran & Dr. K N Lokesh

List of Experiments

1. CDS (Cleaning decontamination and sanitation) for aseptic facility and CIP(Cleaning in place) protocols.
2. Test for sterility: Bacteriological Test for Water for injection (WFI).
3. Determination of antioxidant activity of given formulation by DPPH method
4. Simultaneous estimation of protein/ amino acid in give mixture by spectroscopical method
5. Freezing drying of given protein-based formulation using cryoprotectants.
6. Biopharmaceutics Classification System (BCS): Determination of pH -Partition coefficient of given protein-based formulation
7. Preparation and characterization of blank / loaded liposome
8. Handling and working principles of dissolution test apparatus
9. To profile PK properties of given protein-based formulation by using dissolution test apparatus
10. Computational screening of phytochemicals for antiviral/antibacterial drug discovery
11. Computational modelling and analysis of pharmacokinetics and pharmacodynamics
12. 3D SAR-based pharmacophore modelling and virtual screening of antiviral/antibacterial drugs
13. Molecular dynamics simulations for the protein-ligand complexes
14. Demonstration and SOP of 2D electrophoresis.

Any 12 experiments must be performed.

Reference Books:

1. Gregory Bock, Dalia Cohen, Jamie Goode, Novartis and J. Craig Venter (2001) From Genome to Therapy: Integrating New Technologies with Drug Development, Wiley-VCH.
2. Susanna Wu-Pong, Yongyut Rojanasakul, and Joseph Robinson (2010) Biopharmaceutical Drug Design and Development, Humana Press.

3. Mohammad, A., Moheman, A., & El-Desoky, G. (2012). Amino acid and vitamin determinations by TLC/HPTLC: a review of the current state. *Open Chemistry*, *10*(3), 731-750.
4. Davies, J. G., Gao, D., Kim, Y. J., Harris, R., Cash, P. W., Schofield, T. L., & Qin, Q. (2017). ICH Q5C Stability Testing of Biotechnological/Biological Products. *ICH Quality Guidelines: An Implementation Guide; Wiley: Hoboken, NJ, USA*, 345.
5. Zaia, D. A., Barreto, W. J., Santos, N. J., & Endo, A. S. (1993). Spectrophotometric method for the simultaneous determination of proteins and amino acids with p-benzoquinone. *Analyticachimicaacta*, *277*(1), 89-95.

Web links and Video Lectures (e-Resources):

1. https://www.edx.org/course/principles-of-biomanufacturing-using-biotechnology

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Perform quality control tests to validate quality of product and able to standardize the purity and efficacy of therapeutic compounds (PO-2 & 4)
2. To understand the biopharmaceutical classifications as well as estimate the concentrations of API in a biopharmaceutical component (PO-2 & 4)
3. Develop skill sets to understand basic workflow in pharmaceutical organization (PO-2 & 4)
4. Apply the knowledge of computational modelling for understanding the action of various API formulation for extended release of therapeutics (PO-2 & 4)
5. Improve the research aptitude of students by imparting the knowledge of advanced drug delivery systems and its interaction *insilco* as well as *invitro* (PO-2 & 4)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test	20	CO1, CO2, CO3, CO4 & CO5
Other Components		
Lab assessment	20	CO1, CO2, CO3, CO4 & CO5
Record	10	CO1, CO2, CO3, CO4 & CO5
Semester-End Examination:	50	CO1, CO2, CO3, CO4 & CO5

INDUSTRIAL BIOTECHNOLOGY LAB

Course Code: MBTL27 **Credits:** 1:0:0

Contact Hours: 14P

Course Coordinators: Dr. T P Krishna Murthy & Dr. Chandraprabha M N

List of Experiments

1. Determination of reaction kinetics parameters for free/immobilized enzyme
2. Kinetics studies of growth and substrate utilization of industrially important microorganisms
3. Preparation of Bioreactor: Cleaning, sterilization and calibration of probes
4. Determination of mixing time and volumetric mass transfer coefficient in Bioreactor
5. Bioproduction of ethanol/citric acid/yeast in a bioreactor
6. Kinetics studies of enzyme reaction in a bioreactor.
7. Estimation of isotherm and kinetic parameters for the biosorption process
8. Tangential flow filtration/Membrane separation of bioproducts
9. Design of Experiments: Analysis of screening designs using Design Expert®
10. Design of Experiments Analysis of optimization designs using Design Expert®
11. Simulation of a batch process model for the production of industrial products using SuperPro Designer®
12. Simulation of a fed-batch model for the production of industrial products using SuperPro Designer®
13. Simulation of continuous bioprocess model for the production of industrial products using SuperPro Designer®
14. Techno-economic & Life Cycle Assessment of industrial bioprocess systems using SuperPro Designer®

Reference Books:

1. Das, D., & Das, D. (2021). Biochemical Engineering: A Laboratory Manual. Jenny Stanford Publishing.
2. Alan T. Bull et al. (2014) Manual of Industrial Microbiology and Biotechnology, 3rd Edition, John Wiley & Sons, Inc
3. Moo-Young, M. (2019). Comprehensive Biotechnology, 3rd Edition, Elsevier.
4. Das, D., & Pandit, S. (2021). Industrial Biotechnology. CRC Press.
5. Michael C. Flickinger (2013) Upstream & Downstream Industrial Biotechnology, John Wiley & Sons, Inc

Web links and Video Lectures (e-Resources):

1. Bioreactor Modeling and Simulation Lab: http://38.100.110.143/model/index.html
2. Virtual Bioprocess Engineering Lab: https://biovirtuallab.cms.waikato.ac.nz/
3. Process Control, Reaction Engineering, and Unit Operations Lab: https://uorepc-nitk.vlabs.ac.in/
4. Chemical Process Dynamics Laboratory: http://vlabs.iitkgp.ernet.in/vlabs/vlab14/

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Perform experimental studies and evaluate the kinetic parameters of enzyme reactions through theoretical and empirical models. (PO2 & PO4)
2. Screen and isolate the potential industrially important organisms and apprise their growth kinetics (PO2 & PO4)
3. Explore the features of lab-scale bioreactors and analyze the process parameters that influence the bioreactor efficiency (PO2 & PO4)
4. Apply the principles of separation techniques to isolate and purify the bioproducts from the fermented broth. (PO2 & PO4)
5. Simulate and perform techno-economic evaluation of industrial bioprocess models. (PO2 & PO4)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test	20	CO1, CO2, CO3, CO4 & CO5
Other Components		
Lab assessment	20	CO1, CO2, CO3, CO4 & CO5
Record	10	CO1, CO2, CO3, CO4 & CO5
Semester-End Examination:	50	CO1, CO2, CO3, CO4 & CO5

MULTI-OMIC TECHNOLOGIES

Course Code: MBT31 **Credits:**3:1:0

Contact Hours:42L+14T

Course Coordinators: Dr. Bhavya SG & Dr. Priyadarshini Dey

UNIT-I

Genomics

Genome Sequencing & Genome Projects: Human Genome Project. **DNA sequencing methods:** Sanger dideoxy method, Maxam Gilbert method, Pyrosequencing, Automated Fluorescence method, Introduction to Next Generation Sequencing technology (NGS) and applications of NGS technologies. Comparison of NGS technologies with Sanger sequencing. Workflow of NGS experiments (from experimental design to analysis). **Genome Browsers:** UCSC and Ensemble browser. **Genome analysis:** Types of genome analysis - Denovo sequencing, re-sequencing, transcriptome and epigenetics. **Large scale –model organism sequencing projects:** 1001 genome project, genome 10k project, Drosophila genetic reference panel, 1000 fungal genome project, mouse genome project and million-mutation project.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Link: DNA sequencing methods
https://books.google.fm/books?id=dgmeCAAAQBAJ&printsec=copyright#v=onepage&q=transcri&f=false

UNIT-II

Transcriptomics

Transcriptomics: Classification of transcripts (mRNA, tRNA, rRNA, siRNA, noncoding RNAs). Introduction to de novo approaches and single-cell transcriptomics. Advantages and applications of transciptomics. Microarray and RNA sequencing technologies as transcriptomic platforms (workflow/methods). RNA-seq file formats and basics of experimental design. Data resources to assist in the functional analysis and interpretation of transcriptomic data. Platform level analysis - Background subtraction and correction, summarization and normalization. **Resources and tools for transcriptomics data analysis:** GEO, Array Express, LMMA, SAM, Cluster and TreeView, PANTHER, GSEA, DAVID, GeneXpress.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Link: Introduction to Functional Genomics
Ref: Transcriptomics : DOI: 10.1533/9781908818232.49

Unit-III
Proteomics

Introduction to Proteomics: The life cycle of a protein. Proteomics: introduction, basic principles of proteomics. Overview of analytical proteomics. Evolution from protein chemistry to proteomics. **Ionization techniques:** MALDI and ESI: Concepts, principles and methodology. **Protein sequencing and techniques:** Protein sequencing by Edman technique and LC-MS/MS. **Mass spectrometry-based methods for protein identification:** Proteomics approaches the bottom-up approach and top-down methods. **Generalized proteomics workflow**: sample preparation, fractionation, LC-MS/MS analysis, Bioinformatics analysis. **Qualitative and quantitative proteomics approaches** – quantification methods (TMT and iTRAQ). **Database / tools:** PRIDE proteomics data source, Uniprot, MaxQuant and Human Proteome Map.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Link: Introduction to proteomics

Unit-IV
Metabolomics

Metabolome and Metabolomics: Metabolic profiling and fingerprinting, Metabolomics by NMR, LCMS/MS, GCMS. Metabolic pathway analysis and metabolic networks, Single Cell Metabolomics, Metabotype Concept. Computational Methods to Interpret and Integrate Metabolomic Data, Chemical ontologies. **Online metabolic databases:** Human Metabolome Databases, KEGG, BioCyc and pipelines. Workflows in Metabolomics, Metabolomics Experiments Repositories and Metabolite Databases, Statistical Analysis and Functional Interpretation (Data Input, data cleaning, data normalization, unsupervised methods, supervised approaches, functional analysis). **Applications of Metabolomics:** Metabolic Pathway as a target for Drug-screening, Clinical implications of Metabolomics.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
*Link:*Computational Systems Biology
Metabolome Analysis: 10.1016/B978-0-12-809633-8.20251-3

Unit-V
Integrated OMICS Data Analysis

File formats: Genomic, transcriptomic, proteomic, and metabolomics data file format and standards. **Overview of multi-omics data integration tools:** Tools /software for omics data analysis and visualization, gene set Enrichment analysis, pathway analysis

and network analysis. **Omics Data Types and Repositories:** The Cancer Genome Atlas (TCGA), International Cancer Genomics Consortium (ICGC) and TARGET. **Portals for Visualization and Interpretation of Multi-omics Data Sets**: Firebrowse, cBioPortal, LinkedOmics and others. **Bioconductor R** for Analysis & visualization of genomic data (Heat Map, Volcano plot). Challenges in Multi-omics Data Integration.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Link: Multi-omics integration tools and platforms
Ref: Multi-omics Data Integration, Interpretation, and Its Application. PMID: 32076369
https://www.bioconductor.org/help/course-materials/2019/BiocAsia/02-Workshop.html#analysis-visualization

Text Books:

1. Jonathan Pevsner. (2015). Bioinformatics and Functional Genomics. 3rd edition, Wiley
2. Garciua-Canaas V., Cifuentes A &Simou C. (2014). Fundamentals of Advanced Omics Technologies: From genes to metabolites. 63rd Volume. Elsevier.

Reference Books:

3. Barh, D. & Azevedo V. (2017). Omics Technologies and Bio-engineering. 1st Edition. Elsevier.

Web links and Video Lectures (e-Resources):

1. Omics Genomics, Proteomics, Transcriptomics Biochemistry, and Molecular Biology How Life Works

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Develop sequencing strategies for genome analysis (PO-5)
2. Develop strategies for the analysis of Transcriptomics data (PO-5)
3. Develop sequencing strategies for proteome analysis (PO-5)
4. Develop metabolome analysis strategies for organisms (PO-5)
5. Analysis and visualization of Omics data (PO-5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	Marks	Course outcomes attained
Internal Test-I	30	CO1 & CO2
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
Quiz/Surprise Test	10	CO1, CO2, CO3, CO4 & CO5
Semester-End Examination:	100	CO1, CO2, CO3, CO4 & CO5

FOOD PROCESS ENGINEERING

Course Code: MBTE131 **Credits:** 4:0:0
Contact hours: 42L
Course Coordinator(s): Mr. Gokulakrishnan M

UNIT-I
Properties of Food and Principles of Food Processing

Physical properties, Biochemical properties, Engineering principles on applications of food processing- fluid flow, heat and mass transfer- Effect of heat on microorganisms and enzymes, Effect of heat on nutritional and sensory characteristics of foods, Effect of heat on nutritional and sensory characteristics of foods, Sources of heat and methods of application to foods. Process monitoring and control- sensors, process controllers. Hygienic design, water and waste management.

Pedagogy/Course delivery tools: Chalk and talk, PowerPoint Presentation
Links: https://nptel.ac.in/courses/126105011

UNIT-II
Ambient Temperature Processing of Foods

Raw material preparation, extraction and separation of food components- centrifugation, filtration, extraction, membrane separation, size reduction- size reduction of solid foods, size reduction in liquid foods, mixing- theory of solids and liquid mixing, food biotechnology- Fermentation technology – theory, equipment, commercial food fermentations, effect on foods

Pedagogy/Course delivery tools: Chalk and talk, PowerPoint Presentation
Links: https://nptel.ac.in/courses/126105025

UNIT-III
Thermal Processing of Foods

Thermal destruction of microorganisms, Blanching, cooking, pasteurisation, sterilisation, evaporation, distillation and dehydration- Theory, equipment, effect on foods and microorganisms.

Pedagogy/Course delivery tools: Chalk and talk, PowerPoint Presentation, Videos
Links: https://nptel.ac.in/courses/103107088

UNIT-IV

Low Temperature Preservation

Principles of low temperature preservation, freezing rate and freezing point. Heat removal by refrigeration, cooling and chilling, freezing, freeze drying and freeze concentration- Theory, equipment, effect on foods and microorganisms

Pedagogy/Course delivery tools: Chalk and talk, PowerPoint Presentation, Videos
*Links:*https://nptel.ac.in/courses/126105025

UNIT-V

Post Processing Operations and Manufacture of Food Products

Packaging, Filling and sealing of containers and Materials handling, storage and distribution. Bread and baked goods, dairy products – milk processing, cheese, butter, ice-cream, vegetable and fruit products; edible oils and fats, beverages.

Pedagogy/Course delivery tools: Chalk and talk, PowerPoint Presentation, Videos
*Links:*https://nptel.ac.in/courses/126105013

Text Books:

1. P.J., Fellows, (2022) Food Processing Technology. 5th Edition, Woodhead Publishers.
2. R.T., Toledo, R.K., Singh &Fanbin Kong (2018) Fundamentals of Food Process Engineering. 4th Edition, Springer.
3. P.G., Smith, (2011) Introduction to Food Process Engineering. 2nd Edition, Springer.

Reference Books:

1. B.,Sivasankar, (2002) Food processing and preservation. Prentice Hall of India Pvt.Ltd., New Delhi.
2. B., Zeki, (2009) Food Process Engineering and Technology. Elsevier.
   R.L., Earle, (2003) Unit Operations in Food Processing. 2nd Edition, Pergamon Press. Oxford. U.K

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/126105011
2. https://nptel.ac.in/courses/103107088
3. https://nptel.ac.in/courses/126105018

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Apply the engineering principles to food processing. (PO1)
2. Identify and describe the various operations and biotechnological methods practiced in the food industry. (PO1 & PO3)
3. Apply heat and mass transfer principles for processing and preserving foods. (PO3& 4)
4. Apply the heat removal operations in food industry to extend the shelf life. (PO2 & 3)
5. Analyze various postprocessing operations including packing, filling, sealing and manufacturing process of important food products. (PO1 & 4)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1, CO2
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation	10	CO2, CO4
Numerical test/ Quiz	10	CO1, CO3, CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4, CO5

BIOPROCESS MODELLING AND SIMULATION

Course Code: MBTE132 **Credits:** 3:0:0

Contact Hours: 42L

Course Coordinators: Dr. T P Krishna Murthy & Dr. Chandraprabha M N

UNIT-I

Modeling Principle

Fundamentals of modeling: Use of models for understanding, design, and optimization of bioreactors, general aspects of the modeling approach, general modeling procedure, simulation tools and applications-Development, and meaning of dynamic differential balances: Derivation of a balance equation using rates, formulation of mass balance equations, types of mass balance equations, balancing procedure-Total mass balances: component balances for reacting systems-Stoichiometry and metabolite and elemental balancing, metabolic network stoichiometry, thermodynamics, and equilibrium relationships.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation

Links: Review on Bioprocess Systems Engineering

https://doi.org/10.5936/csbj.201210022

UNIT-II

Biological Kinetics

Enzyme Kinetics: Reaction equilibrium, Michaelis–Menten equation, other enzyme kinetic models, double Michaelis–Menten kinetics- Inhibition: Substrate inhibition, allosteric kinetics, temperature and pH influence, enzyme deactivation. Microbial Kinetics: Basic growth kinetics, cell death and sterilization, specific rates, Monod growth kinetics, substrate inhibition of growth, product inhibition, substrate uptake kinetics, product formation, interacting (micro-)organisms. structured kinetic models, types of structured kinetic models, and modeling of metabolic networks.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation

Link: 1. ENZYMES: Catalysis, Kinetics and Mechanisms

https://link.springer.com/book/10.1007/978-981-13-0785-0

2. Stoichiometry of Biochemical Reactions and Cell Growth. In: Hu, W. S. (2017). Engineering Principles in Biotechnology. John Wiley & Sons.

https://onlinelibrary.wiley.com/doi/10.1002/9781119159056.ch3

UNIT-III

Bioreactor Modelling

Bioreactor Operation: Batch operation, semicontinuous or fed-batch operation & continuous operation. Case studies on General Balances for Tank-type biological reactors: continuous fermentation with biomass recycle, enzymatic tanks-in-series bioreactor system, modelling tubular plug flow bioreactors, steady-state balancing, unsteady-state balancing for tubular bioreactors.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Link: Chapter 14 - Reactor Engineering. In: Pauline M. Doran (2013) Bioprocess Engineering Principles (Second Edition). Elsevier
https://www.sciencedirect.com/science/article/pii/B9780122208515000149

UNIT-IV

Mass Transfer Modelling

Mass transfer in biological reactors: gas absorption with bioreaction in a liquid phase, liquid–liquid extraction with bioreaction in one phase, surface Biocatalysis, diffusion and reaction in porous biocatalyst, interphase gas–liquid mass transfer, general oxygen balances for gas–liquid transfer, application of oxygen balances external mass transfer, internal diffusion and reaction within biocatalysts, derivation of finite difference model for diffusion–reaction flat plate systems, finite difference model for diffusion–reaction in a sphere, dimensionless parameters from diffusion–reaction models, the effectiveness factor concept.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Link: Chapter 13 - Heterogeneous Reactions. In: Pauline M. Doran (2013) Bioprocess Engineering Principles (Second Edition). Elsevier
https://www.sciencedirect.com/science/article/pii/B9780122208515000149

UNIT-V

Automatic Bioprocess Control

Elements of feedback control, measurement of process variables: Sensors used in biotechnology, calculated measured variables, dynamic characteristics of measurement. types of controller action: on–off control, proportional (P) controller,proportional–integral (PI) controller, proportional–integral–derivative (PID) controller. controller tuning: trial and error method, Ziegler–Nichols method, ultimate gain method, error integrals for characterization of controller performance. Advanced control strategies: Cascade control, feed-forward control, adaptive control, and other types of advanced control. application strategies of bioprocess control.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Link: Bioprocess Control: Current Progress and Future Perspectives https://doi.org/10.3390/life11060557

Text Books:

1. Heinzle, E., Dunn, I. J., Ingham, J., & Přenosil, J. E. (2021). Biological Reaction Engineering: Dynamic Modeling Fundamentals, 2nd Edition. John Wiley & Sons.
2. Verma, A. K. (2014). Process modeling and simulation in chemical, biochemical and environmental engineering. CRC Press.
3. Ravi, R., Vinu, R., & Gummadi, S. N. (Eds.). (2017). Coulson and Richardson's Chemical Engineering: Volume 3A: Chemical and Biochemical Reactors and Reaction Engineering. Butterworth-Heinemann.

Reference Books:

1. Moo-Young, M. (2019). Comprehensive Biotechnology, 3rd Edition, Elsevier.
2. Dominic Foo (ed.). (2022). Chemical Engineering Process Simulation. Process Integration and Optimization for Sustainability, 2nd Edition, Elsevier.
3. Upreti, S. R. (2017). Process modeling and simulation for chemical engineers: Theory and practice. John Wiley & Sons.
4. Chidambaram, M. (2018). Mathematical Modelling and Simulation in Chemical Engineering. Cambridge University Press.
5. Ghasem, N. (2018). Modeling and simulation of chemical process systems. CRC Press.
6. Rohani, S. (2017). Coulson and Richardson's Chemical Engineering: Volume 3B: Process Control. Butterworth-Heinemann.
7. Hu, W. S. (2017). Engineering Principles in Biotechnology. John Wiley & Sons.

Web links and Video Lectures (e-Resources):

1. Mathematical Modelling: Analysis and Applications: https:// nptel.ac.in/courses/111/107/111107113/
2. Modelling and Simulation of Dynamic Systems: https:// nptel.ac.in/courses/112/107/112107214/
3. Introductory Mathematical Methods for Biologists: https:// nptel.ac.in/courses/102/101/102101067/
4. Advanced Mathematical Techniques in Chemical Engineering: https:// nptel.ac.in/courses/103/105/103105106/
5. Mathematical Methods in Engineering and Science:
6. https:// nptel.ac.in/courses/112/104/112104035/

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Describe the role of modeling and simulation in understanding bioprocesses and biological systems (PO-3, PO4, PO5).
2. Develop mathematical models for studying the kinetic behavior of biosystems (PO-3, PO4, PO5).
3. Formulating the bioreactor theory in terms of mathematical equations to predict behavior that can be compared with experimental data (PO-3, PO4, PO5).
4. Analyze the influence of mass transfer in multiphase bioreaction systems (PO-3, PO4, PO5).
5. Analyze the importance of control systems in bioprocesses that aim for high product yields as well as high process stability and repeatability (PO-3, PO4, PO5).

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 & CO2
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
Quiz/Surprise Test/Tutorial Test	10	CO1, CO2, CO3, CO4 & CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4 & CO5

CURRENT TRENDS IN DRUG DISCOVERY & RSEARCH

Course Code: MBTE133 **Credits:** 3:0:0

Contact Hours: 42L

Course Coordinators: Dr. Lokesh. K. N.

UNIT-I

Introduction to Drug Discovery

Drug discovery: past, present and future; Prospects of Drug discovery in Drug Development of Process., Basic strategies of drug discovery: Target selection, hit identification, lead optimization, and identification of clinical candidates., Introduction to regulatory frameworks and clinical trials.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation.
Links for topic: https://nptel.ac.in/courses/104106106

UNIT-II

Classical Targets and Tools of Drug Discovery

Targets: Classification of receptors, G-protein-coupled receptors, Ion channels, Membrane transport proteins (transporters), Nuclear receptors, etc., Tools of drug discovery: X-ray crystallography, Molecular modelling and computational chemistry, High-throughput technology: chemical synthesis and screening science, DNA Sequencing and genomics, Proteomics, and other recent techniques.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation.
Links for topic: https://nptel.ac.in/courses/104106106

Unit-III

In vitro ADME profile and *In vitro* screening assays

Concepts of ADME: Absorption, distribution, metabolism and excretion and relevant pharmacokinetic and pharmacodynamic parameters., *In vitro* screening: Basic terminologies of *in vitro* screening, Radioligand systems, Enzyme-linked immunosorbent assay, Reporter gene assays, Label-free assay systems, Electrophysiological patch clamp, etc., General consideration for all screening methods.
Pedagogy/Course delivery tools: Chalk and talk and Power point presentation.
Links for topic: NA

Unit-IV

Animal models and *In vivo* assays

Different animal models used for *In vivo* screening selection criteria, Animal models of oncology, Animal models of cardiovascular disease, Animal models of infectious disease, Animal models of neurodegeneration.
Pedagogy/Course delivery tools: Chalk and talk and Power point presentation.
Links for topic: NA

Unit-V

Drug discovery prospects of Medicinal chemistry

Medicinal chemistry: structure-activity relationships and structure-property, relationships., Push and pull in structure-activity relationships., Quantitative structure-activity relationships., The pharmacophore Developing structure-activity relationship data set., structure-activity relationship, selectivity, and physicochemical properties "Drug-like" guideline
Pedagogy/Course delivery tools: Chalk and talk and Power point presentation.
Links for topic: https://nptel.ac.in/courses/104106106

Text Books:

1. Blass, B. E. (2015). *Basic principles of drug discovery and development*. Elsevier.
2. Walsh, G. (2013). *Biopharmaceuticals: biochemistry and biotechnology*. John Wiley & Sons.
3. Crommelin, D. J., Sindelar, R. D., &Meibohm, B. (Eds.). (2013). *Pharmaceutical biotechnology: fundamentals and applications*. Springer Science & Business Media.

Reference Books:

1. Chorghade, M. S. (Ed.). (2006). *Drug discovery and development*. Hoboken, NJ: Wiley-Interscience.
2. Rastogi, S. C., Rastogi, P., & Mendiratta, N. (2022). *Bioinformatics: Methods and Applications-Genomics, Proteomics and Drug Discovery*. PHI Learning Pvt. Ltd..
3. Wolff, M. E. (1996). Burger's medicinal chemistry and drug discovery. *American Journal of Therapeutics*, *3*(8), 608.

Web links and Video Lectures (e-Resources):

.https://www.coursera.org/lecture/drug-discovery/drug-discovery-proteomics-genomics-i-A3leH

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. To understand the prospects of drug discovery in drug development process. (PO: 1,3,5).
2. To understand the significance of different types of biomarkers expressed and their importance in drug discovery. (PO: 1,3,5)
3. To assess the efficiency *in vitro* screening in drug discovery (PO: 1,3,4,5).
4. To assess the efficiency *in vivo* screening in drug discovery (PO: 1,3,4,5).
5. Exploring the importance of medicinal chemistry in drug designing (PO: 1,3,4,5).

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1, CO 2
Internal Test-II	30	CO , CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
Tutorial Test	10	CO1, CO2, CO3, CO4 & CO5
Semester-End Examination:	100	CO1, CO2, CO3, CO4 & CO5

BIOMATERIALS AND MEDICAL DIAGNOSTICS

Course Code: MBTE141 **Credits:** 4:0:0

Contact Hours: 56L

Course Coordinators: Dr. Roshni Ramachandran

UNIT-I

Introduction to Biomaterials

Introduction to basic concepts of materials science, need and scope for biomaterials and biomedical devices, historical development in biomaterials, metals (stainless steel, cobalt-chromium alloys, titanium alloys etc.), ceramics (alumina, zirconia, etc.), polymers (thermoplastics, thermosets, elastomers, hydrogels etc.), carbon (pyrolytic carbon, graphite, activated carbon, carbon nanotubes, etc.), composites (polymer matrix, ceramic matrix, metal matrix composites).

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://freevideolectures.com/course/3086/introduction-to-biomaterials
Introduction to Biomaterials by Prof. BikramjitBasu,Prof.kanteshBalani, Department of Materials & Metallurgical Engineering, IIT Kanpur.

UNIT-II

Concept of Biocompatibility

Fundamentals of human biology and anatomy: cell, tissues and systems. Biocompatibility: Tissue-biomaterial interactions: interaction between the biomaterial surface and the tissue, effect of biomaterials on cells, Bioactivity: Effect of biomaterials on the biological tissues, responses of the body to implantation. Biodegradability

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: http://freevideolectures.com/Cour se/3086/Introduction-toBiomaterials/3

UNIT-III

Tissue engineering and Drug delivery

Basics of tissue engineering. Components of tissue engineering, scaffolds, biomaterials in hard tissue replacement, biomaterials in 3D printing/bio-printing techniques. Bioreactors for tissue engineering. In vivo cell & tissue engineering. Basics of drug delivery: Mechanisms of Drug Delivery, Protein-Drug Properties, Drug Delivery in Tissue engineering.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation

*Links:*https://blog.nus.edu.sg/chbewch/drug-delivery/tissue-engineering-and-drug-delivery/
https://archive.nptel.ac.in/courses/102/106/102106036/

UNIT-IV

Biomaterial characterization

Biomaterial characterization techniques - Rheology, Atomic Force Microscopy, Electron Microscopy, Transmission Electron Microscopy Fourier Transform Infrared Spectroscopy, in vitro, ex vivo and in vivo characterization of cell–biomaterials interactions.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://www.sciencedirect.com/topics/materials-science/biomaterials-characterization

UNIT-V

Medical Diagnostics

Introduction to Medical Diagnostics. Physiological concepts for understanding the choice of diagnostics tools. Bodily fluids in Medical Diagnostic: Composition of various body fluids for diagnostic purposes mainly blood cells and other components from blood samples and the type of diagnostic information blood-based analyses can provide. Diagnostic techniques. Methods to detect, identify and isolate pathogenic agents from body tissues and fluids. Medical Imaging in Diagnostics: Overview of common radiological and sensing methods used in a clinical setting to visualize internal structures for diagnostic purposes.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://www.youtube.com/watch?v=3wp_EvMYgRQ

Text Books:

1. Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratner, Hoffman, Schoet and Lemons, Second Edition: Elsevier Academic Press, 2004
2. Biomaterials: Principles and Applications by J.B. Park and J.D. Bronzino.
3. Manual of Diagnostics and Laboratory Tests, 6th Edition, Kathleen Pagana and Timothy Pagana

Reference Books:

1. Biomaterials Science and Biocompatibility, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.

2. Tanzi, M. C., Farè, S., & Candiani, G. (2019). Foundations of Biomaterials Engineering. Academic Press.
3. Dos Santos, V., Brandalise, R. N., & Savaris, M. (2017). Engineering of biomaterials. Berlin, Germany: Springer.
4. Wong, J. Y., Bronzino, J. D., & Peterson, D. R. (Eds.). (2012). Biomaterials: Principles and Practices. CRC Press.
5. Reis, R. L. (2019). Encyclopedia of tissue engineering and regenerative medicine. Academic Press.
6. Lab Manual on Blood Analysis and Medical Diagnostics. Dr. Gayatri Prakash

Web links and Video Lectures (e-Resources):

1. Introduction to basic concepts of Biomaterials Science; Salient properties of important material classes
http://textofvideo.nptel.iitm.ac. in/113104009/lec1.pdf
https://www.youtube.com/watch?v=yZKdFVAJcrE&list=PLgFamYl9tu7qlBKz50mYdgaOHwIwRT6Fv&index=1&spfreload=10
http://freevideolectures.com/Cour se/3086/Introduction-toBiomaterials/2
http://www.freestudy.co.uk/HN C%20MATERIALS%20UNIT %2021/1t3.pdf

2. Concept of Biocompatibility
https://www.youtube.com/watch? v=VU3gihrRaQ&list=PLgFamYl9tu7qlBKz 50mYdgaOHwIwRT6Fv&index= 3
http://freevideolectures.com/Cour se/3086/Introduction-toBiomaterials/3
http://www.bioen.utah.edu/facu lty/pat/Courses/biomaterials/Bi ologicalResponse.pdf

3. Tissue Engineering and Drug Delivery
https://www.slideshare.net/sushmithagowtham/tissue-engineering-52936324
https://in.video.search.yahoo.com/search/video?fr=mcafee&ei=UTF-8&p=drug+delivery+and+biomaterials+videos&vm=r&type=E211IN826G0#id=1&vid=3f1fe7df86ec66761c5d4a71fb55a4ec&action=click

4. Biomaterial Characterisation
https://onlinecourses.nptel.ac.in/noc22_mm37/preview
http://ecoursesonline.iasri.res.in/mod/page/view.php?id=1010

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Classify the biomaterials and recognize their production and properties. (PO1,4,5)

2. Recognize the importance of relationships between living tissues and biomaterials (PO
4,5)
3. Apply the knowledge of biomaterials in tissue engineering and drug delivery (PO1,4,5)
4. Understand how to characterise the surface properties as well the composition and mechanical
strength of a biomaterial (PO 4,5)
5. Describe disciplines and specimen types appropriate diagnostics tools within the field of medical diagnostics (PO1,3,4,5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 & CO2
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
Quiz/Surprise Test	10	CO1, CO2, CO3, CO4 & CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4 & CO5

ENVIRONMENTAL BIOTECHNOLOGY

Course Code: MBTE142 **Credits:** 4:0:0

Contact Hours: 56L

Course Coordinators: Dr. Bhavya S G & Dr. Ahalya N

UNIT-I

Environmental Pollution

Environmental Biotechnology – Principles and concepts –usefulness to mankind. Environmental pollution- sources and nature. Pollution monitoring/measurement. Biotechnological remedies for environmental pollution- decontamination of ground water bioremediation– Production of proteins- biofertilizers – Physical, chemical and microbiological factors of composting – health risk- pathogens- odor management.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://onlinecourses.nptel.ac.in/noc21_bt41/preview

UNIT-II

Biotechnology Tools for Environmental Management

Molecular biology tools for Environmental management, rDNA technology in waste treatment, Genetically modified organisms in Waste management, Genetic Sensors, Metagenomics, Bioprospecting, Nanoscience in Environmental management, Phytoremediation for heavy metal pollution, Biosensors development to monitor pollution

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://actascientific.com/ASAG/pdf/ASAG-03-0721.pdf

UNIT-III

Water Pollution and Sewage Waste Water Treatment

Nature of water pollutants, waste water and sewage, Measurement of water pollution, Classification of treatment process: primary treatment, secondary or biological treatment, tertiary treatment. Water recycling- small sewage waste water treatment systems.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://nptel.ac.in/courses/105106119

UNIT-IV

Sludge and Solid Waste Treatment and Disposal

Sources and characteristics of sludge, sludge thickening, sludge stabilization, conditioning of sludge, Disinfection of sludge, dewatering, heat drying, ultimate disposal of sludge. Hazardous waste management - Bioremediation, Biological detoxification- examples of biotechnological applications for hazardous waste management. Mining and Metal biotechnology, microbial transformation, accumulation and concentration of metals, metal leaching, extraction and future prospects. Biomedical waste.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://onlinecourses.nptel.ac.in/noc22_ce76/preview

UNIT-V

Treatment of Industrial Wastes

Industrial waste management- Dairy, Paper & Pulp, Textile, leather, hospital and pharmaceutical industrial waste management, e-waste- radioactive and nuclear power waste management- Solid waste management. Treatment of antibiotics in waste water. Carbon footprint, Recycle carbon, Environmental policy case studies.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://nptel.ac.in/courses/105107207

Text Books:

1. Metcalf & Eddy, (2003). *"Wastewater Engineering"*, 4th edition, TATA-McGraw Hill.
2. Hammer M J, (1989). *"Water and Wastewater Technology",* 2nd edition, John Wiley & Sons.
3. Davis M L, Corwell D A, (1991). *"Introduction to Environmental Engineering",* 2nd edition, Mc Graw Hill.

Reference Books:

1. Peavy H S, Rowe D R, (1985). *"Environmental Engineering",* Mc Graw Hill.
2. Eckenfelder W W, (1991). "*Industrial Water Pollution Control",* 2nd edition, Mc Graw Hill.

Web links and Video Lectures:

1. Water and waste water treatment

https://onlinecourses.nptel.ac.in/noc21_ce25/preview

2. Wastewater Treatment and Recycling

https://onlinecourses.nptel.ac.in/noc19_ce32/preview

Course Outcomes (COs):

At the end of the course, Students will have the ability to:

1. Assess the biological treatment techniques for waste water. (PO1 & PO4)
2. Apply the biotechnological processes and principles of waste management to protect the environment. (PO3)
3. Appraise the suitability of the design of treatment plants and unit processes. (PO4 & PO5)
4. Understand the management of residuals from wastewater treatment. (PO4, PO5)
5. Apply the principles of waste management to treat the effluents from industries. (PO1 & PO5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 & CO2
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
Quiz/Surprise Test	10	CO1, CO2, CO3, CO4 & CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4 & CO5

PROTEIN ENGINEERING

Course Code:MBTE143 **Credits:** 4:0:0

Contact Hours: 56L

Course Coordinators: Dr Prabha M

UNIT -I

Fundamentals and Characterization of Protein engineering

Definition, principles, applications; Features or characteristics of protein that can be engineered-affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensies etc. Forces stabilizing proteins - Van der waals, electrostatic; hydrogen bonding weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation;

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
*Links:*https://library.um.edu.mo/ebooks/b2805488x.pdf

UNIT-II

Experimental Methods of Protein Engineering and Protein Design

Outline of bioengineering of macromolecules a multidisciplinary approach; Methods to alter primary structure of protein: *ab- initio* method for protein structure prediction, Cell-free protein engineering technologies, Examples of engineered proteins, Protein design, *In silico* protein engineering: Methods and Tools. Protein modeling to the desired needs. Random and Site directed mutagensis; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; Optimization and high throughtput screening methodologies like Giga Metrix, High throughput microplate screens etc.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links:
https://cdn.intechopen.com/pdfs/29172/intech-protein_engineering_methods_and_applications.pdf
http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S001174BS/P001209/M014200/ET/1526986988P14_M24_ET.pdf

UNIT-III

Control of Protein Function

Mechanisms of Regulation, Analytical methods to determine the structure and stability of protein , Protein -protein interactions, Yeast two hybrid system, Cell surface and phage display technologies. Effector Ligands: Competitive Binding and Cooperativity,

Conformational Change and Allostery, Protein Switches Based on Nucleotide Hydrolysis, Regulation by Degradation, Control of Protein Function by Phosphorylation, Applications of protein engineering in GFP evolution.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links:
https://samples.jbpub.com/9781449600914/86632_ch02_027_074.pdf
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7274900/
http://www.velhightech.com/Documents/BT6501-PSFP.pdf

UNIT-V

Therapeutic Protein Engineering

Frontier for Protein Therapeutics, Engineering protein molecules to medicine, Examples of Protein Therapeutics: Monoclonal Antibody Therapeutics, Enzyme Therapeutics Acting on Extracellular Targets. Protein Therapeutics as Replacements for Defective or Deficient Proteins: Protein Hormones, Coagulation Factors, Medicinal Protein Engineering: Protein Engineering for Cardiovascular Therapeutics and protein therapeutics to cross the blood-brain barrier, engineering growth factors for regenerative medicine applications

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links:
https://link.springer.com/article/10.1134/S0006297922140127
https://cheresearch.engin.umich.edu/wen/Bookchapter-Therapeutic%20protein%20engineering.pdf

UNIT-V

Protein Biocatalysis and Enzyme engineering

Random and rational approach of protein engineering; Directed evolution and its biocatalysis applications; De novo enzyme design; Various approaches of creating variant enzyme molecules; The design and construction of novel enzymes, artificial enzymes, Future of biocatalysis; Ideal Biocatalyst. Stabilization of Industrial Enzymes by Protein Engineering Engineeringß-Glycoside Hydrolases. Enzymes for analytical and diagnostic applications, Design of catalytic proteins – Esterase activity.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links:

https://ocw.mit.edu/courses/7-344-directed-evolution-engineering-biocatalysts-spring-2008/pages/lecture-notes/

Text Books

1. Uwe T. Bornscheuer, Stefan Lutz Vol 3 (2012) Protein Engineering Handbook, WILEY -VCH publications.
2. Caroline Koehrer, Uttam L. Raj Bhandary (2009) Protein engineering. Springer publications
3. Jennifer R. Cochran, Sheldon J. Park (2009) Protein engineering and Design, CRC press

References:

1. Mueller and Arndt (2006) Protein Engineering protocols, Ist Edition, Humana Press.
2. KhudyakovY.E.(2008) "Medicinal Protein Engineering", CRC Press, 1st Edition.
3. Yoo, Y.J., Feng, Y., Kim, Y.-H., Yagonia, C (2017) "Fundamentals of Enzyme Engineering", 1st edition, Springer Netherlands.
4. Ed. Robertson DE, Noel JP, (2004) Protein Engineering Methods in Enzymology, 388 Elsevier Academic Press.
5. Lilia Alberghina (2002) Protein engineering in Industrial biotechnology. Harwood Academic Publishers.

Course Outcomes

On completion of this course student will have the improved ability to:

1. Evaluate the parameters and characteristics of protein for engineering them. (PO3, PO4 & PO5)
2. Identify different approaches for the protein design and construction. (PO1, PO3, PO4 & PO5)
3. Apply concepts of regulatory mechanisms of proteins to modify their function. (PO3, PO4 & PO5)
4. Analyze various protein therapeutics engineered for applications in Healthcare. (PO4 & PO5)
5. Apply Biocatalysis and protein engineering concepts in industrial applications. (PO4 & PO-5)

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/102101055
https://archive.nptel.ac.in/courses/102/105/102105089/

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation	10	CO1, CO2 & CO3
Quiz/Mini Project write up	10	CO4 & CO5
Semester End Examination:	50	CO1, CO2, CO3, CO4 & CO5

EXPERIMENTAL DESIGN AND ANALYSIS

Course Code: MBTE151 **Credits:** 4:0:0

Contact Hours: 56L

Course Coordinators: Dr. M. Girinath Reddy

UNIT-I

Random variables-discrete and continuous, Mathematical expectation and its laws, Moments, coefficient of skewness and kurtosis. Probability distributions - Bernoulli/Binomial, Poisson, Geometric, Normal. Joint probability distributions for discrete and continuous random variables, conditional expectation, stochastic independence.

- Pedagogy / Course delivery tools: ➢ Chalk and talk.
- Links: ➢ https://nptel.ac.in/courses/111/105/111105035/
- Impartus Recording: ➢ https://a.impartus.com/ilc/#/course/96151/1112

UNIT-II

Correlation, Regression analysis, Partial and multiple correlation and regression, Regression diagnostics - residuals, multi collinearity, testing adequacy of fit and validation in regression analysis; Sampling distribution of correlation and regression coefficients; Testing of hypothesis: z – test, t-test, Chi-square test and F-test.

- Pedagogy / Course delivery tools: ➢ Chalk and talk.
- Links: ➢ https://nptel.ac.in/courses/111/105/111105035/
- Impartus Recording: ➢ https://a.impartus.com/ilc/#/course/96151/1112

UNIT-III

Concept of analysis of variance (ANOVA) for one-way and multi-classified experiments; Multiple Mean Comparison, Pair wise Contrasts, Type of Models (Fixed or Random), Incomplete Blocks/Missing data Fisher's principles, Basics of designing an experiment.

Completely Randomized Design (CRD), Principles and Usage, Randomization, Data Analysis/Model (one-way ANOVA), Advantages/Disadvantages, Ideal Conditions. Randomized Complete Block Design (RCBD), Data Analysis, Advantages and disadvantages, Comparison with CRD.

- Pedagogy / Course delivery tools: ➢ Chalk and talk.
- Links: ➢ https://nptel.ac.in/courses/110105087
- Impartus Recording: ➢ https://a.impartus.com/ilc/#/course/96151/1112

UNIT-IV

Latin Square Design, Construction and arrangement, Analysis, Relative efficiency of LSD over CRD and RCBD. Graeco Latin Square Design: Construction and arrangement, data analysis.

Factorial Experiments: 2^2 and 2^3 Designs, the general 2^k Design, Methods to find the factorial effects, Yate's algorithm of computing factorial effects.

- Pedagogy / Course delivery tools: ➢ Chalk and talk.
- Links: ➢ https://nptel.ac.in/courses/110105087

UNIT-V

Blocking and confounding, blocking a 2^k factorial design, Confounding in 2^k factorial design, Partial and Complete Confounding. Two level fractional factorial designs, One half fraction of the 2^k design, One quarter fraction of the 2^k design. Plackett- Burman design, Analysis of Covariance (ANCOVA), Assumptions and Model for ANCOVA, Statistical analysis.

- Pedagogy / Course delivery tools: ➢ Chalk and talk.
- Links: ➢ https://nptel.ac.in/courses/110105087

Test books:

1. Douglas C. Montgomery (2009) Design and Analysis of Experiments, 7th Edition, Wiley publication.
2. Misra BL (2005) Design & Analysis of Experiments for Agricultural Workers, 1st Ed, Kalyan Pub.

References:

1. Sundararaj N, Nagaraju S, Ramu MNV, Jagannath MK (1972) Design and analysis of field experiments. Miscellaneous Series, University of Agricultural Sciences, Bangalore.

3. Steel & Torrie (1980) Principals and Procedures of Statistics A Biometrical Approach.
4. Kirk (1995) Experimental Design, Procedures for the Behavioral Sciences.
5. Kuehl (2000) Design of Experiments: Statistical Principals of Research Design and Analysis.

Course Outcomes:

On completion of this course student will have improved ability to

1. Identify the random variables and use standard discrete and continuous probability distributions. (PO4)
2. Perform test of hypothesis for a given data using parametric and nonparametric tests. (PO4)
3. Apply one way and two way ANOVA for CRD and RCBD. (PO4, PO5)
4. Apply three way and four way ANOVA for Latin Squares and Graeco Latin Squares and construct a factorial experiment. (PO4, PO5)
5. Apply Blocking and construct fractional factorial design. (PO4, PO5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment Tool	**Marks**	**Course outcomes addressed**
Internal Test-I	30	CO1, CO2
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other components	**Marks**	**Course outcomes addressed**
Quiz	10	CO1, CO2, CO3
Assignment	10	CO1, CO2, CO3, CO4, CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4, CO5

BIOREACTOR TECHNOLOGY

Course Code: MBTE152 **Credits:** 4:0:0

Contact Hours: 56L

Course Coordinators: Dr. Chandraprabha M N & Dr. T P Krishna Murthy

UNIT-I

Introduction to Bioreaction and Bioreactors

Overview of biological reactions and bioproducts. Purpose and importance of bioreactors in bioprocess industries, Requirements for a bioreactor, Development of bioreactors, classification of bioreactors. Elements in bioreactor design. Major components of bioreactor and their purpose, Basics of energy transfer and mass balance. Biochemical engineering aspects of bioreactors. Bioreactor configurations. Classification of bioreactors based on application: Microbial Process, Mammalian cell culture, plant cell culture, immobilized catalyst, environmental applications.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Link: Villadsen, J., Nielsen, J., &Lidén, G. (2011). Bioreaction engineering principles. Springer Science & Business Media.
https://link.springer.com/book/10.1007/978-1-4419-9688-6

UNIT-II

Bioreactors for Submerged Liquid Fermentation (SLF)

Batch Bioreactors, Continuous Flow Bioreactors, Semi-Continuous Bioreactors, Recycle Bioreactors, Combination of Bioreactors-Bioreactors for enzyme reactions and Immobilized Cells-Rheological properties of fermentation broths-Mixing in bioreactors- Gas-liquid hydrodynamics- Heat transfer process in SLF, Mass transfer in SLF-Molecular diffusion, Oxygen uptake and solubility. Role of aeration and agitation SLF bioreactors. Case studies of SLF in bioproducts production.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Link: Industrial Bioreactors for Submerged Fermentations
https://doi.org/10.1201/b14070

UNIT-III

Bioreactors for Solid State Fermentation (SSF)

General Considerations about Solid-state Fermentation Processes- Factors Affecting Solid-state Fermentation- Aerobic and anaerobic Solid-State Fermentation- Kinetics in Solid-state Fermentation- Water Relations in Solid-state Fermentation- Heat and Mass Transfer in Solid-State Fermentation Bioreactors- Aspects of Design of Bioreactors in

SSF- Scale-up Challenge for SSF Bioreactors- Groups of SSF Bioreactors: Unaerated and Unmixed, Forcefully-Aerated Bioreactors Without Mixing, Rotating-Drum and Stirred-Drum Bioreactors, Continuously-Mixed, Forcefully-Aerated Bioreactors, Intermittently-Mixed Forcefully-Aerated Bioreactors, Continuous Solid-State Fermentation Bioreactors. Instrumentation and Controls in SSF-Case studies.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Link: Bioreactors in solid state fermentation technology
https://doi.org/10.1016/j.jbiotec.2018.01.010

UNIT-IV

Bioreactors for Cell Culture Technology

An Overview of Cell Culture Technology and its application importance in biopharmaceutical industries. Cell Culture Bioreactors, Aeration, Mixing and Hydrodynamics in Cell culture Bioreactors. Instrumentation and Process Control. Perfusion bioreactors, hallow fibre bioreactors. Disposable/ Single-Use Bioreactors for mammalian cells. Bioreactors for Immobilized biocatalysts. Fed-Batch Cultivation of Mammalian Cells. Bioreactor systems for tissue engineering. Design of Bioreactors for Plant Cell and Organ Cultures. Bioreactors for bioartificial Organs. Plant Bioreactor for Bioactives. Production of Biomass and Bioactive Compounds Using Bioreactor Technology.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Link: Bioreactors for cell therapies https://doi.org/10.1016/j.jcyt.2016.09.011

UNIT-V

Membrane Bioreactors (MBR)

Principle of MBR, Brief History of MBR Technology-Comparison of CAS and MBR Processes- Operational Condition and Performance of MBR- Direction in Research and Development (R&D) of MBR-Biological Wastewater Treatment-Microbial Stoichiometry and kinetics in MBR-Membranes, Modules, and Cassettes-Membrane Fouling-MBR Operation: Operation Parameters, Aeration for Biotreatment and Membrane Aeration- Design of MBR. Bioreactors for waste gas treatment. Case studies

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Link: Current state and challenges of full-scale membrane bioreactor applications https://doi.org/10.1016/j.biortech.2018.09.061

Textbooks:

1. Tapobrata Panda. (2011) Bioreactors: Analysis and Design, 1st Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2011.
2. Michael C. Flickinger. (2013) Upstream Industrial Biotechnology. John Wiley & Sons, Inc.
3. Morchain, J. (2017). Bioreactor Modeling: Interactions Between Hydrodynamics and Biology. Elsevier.

Reference Books:

1. Mandenius, C. F. (2016). Bioreactors: design, operation and novel applications. John Wiley & Sons.
2. Chen, H. Z. (2013). Modern Solid-State Fermentation: Technology-Theory and Practice.
3. Hee-Deung Park, In-Soung Chang, Kwang-JinLee.(2015) Principles of Membrane Bioreactors for Wastewater Treatment. CRC Press
4. Kee-YoeupPaek, Hosakatte Niranjana Murthy Jian-Jiang Zhong. (2014) Production of Biomass and Bioactive Compounds Using Bioreactor Technology., Springer Science+Business Media Dordrecht.
5. Sarfaraz K. Niazi. (2012) Disposable Bioprocessing Systems, CRC Press.
6. Saha, G., Barua, A., & Sinha, S. (2017). Bioreactors: Animal Cell Culture Control for Bioprocess Engineering. CRC Press.

Web links and Video Lectures (e-Resources):

1. Bioreactor Design and Analysis https://nptel.ac.in/courses/102/106/102106086/
2. Bioreactors https://nptel.ac.in/courses/102/106/102106053/
3. Cell cultivation techniques: An introduction https://www.edx.org/course/cell-cultivation-techniques-an-introduction

Course outcome (COs):

On completion of this course student will have the improved ability to:

1. Comprehend the principles of design, operation and major components of industrial bioreactors. (PO1 & PO4)
2. Compare the parameters which affect various submerged fermentation bioreactors. (PO1, PO3, PO4 & PO5)
3. Analyze the design aspects of solid-state fermentation bioreactors. (PO3, PO4 & PO5)
4. Apply concepts of bioreactor design for cell culture technologies. (PO3, PO4 & PO5)

5. Conceptualize the principles of Membrane bioreactors and utilize them for various industrial applications. (PO3, PO4 & PO5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 & CO2
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
Quiz/Surprise Test/Tutorial Test	10	CO1, CO2, CO3, CO4 & CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4 & CO5

ADVANCED CELL CULTURE & ANIMAL BIOTECHNOLOGY

Course Code:MBTE153 **Credits:** 4:0:0

Contact Hours: 56L

Course Coordinators: Dr. Abhijith S.R

UNIT-I

Animal Cell culture

Introduction and history of animal cell culture**,** Basic set up of animal cell culture lab**,** Biology of cells in Culture**,** Function of different constituent of cell culture media. Serum and protein free media and their applications, Cell culture techniques: Monolayer and suspension culture, cell lines, Continuous cell lines, Primary and immortalized cells, Cell transformation and malignancy. Organ culture- techniques, three-dimensional culture and Artificial organs, 3D printing. Cryopreservation and storage of animal cells, Cell culture contamination and detection.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://nptel.ac.in/courses/102104059

UNIT-II

Techniques in Cell culture and Applications

Microscopic techniques: Electron microscopy, fluorescent and phase contrast microscopic studies. Cell proliferation assays, Cell Synchronization, Flow cytometry and its applications in cell culture. Somatic cell fusion and its applications. Gene transformation: Viral, physical and chemical mediated gene delivery into cells. Immuno-techniques: Immunocytochemistry, Western blotting to detect various proteins.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://nptel.ac.in/courses/102104059

UNIT-III

Assisted animal Breeding and Transgenic Technology

Artificial insemination, *in vitro* fertilization and embryo transfer, Super ovulation, Embryo sexing, Nuclear transplantation and cell cloning, Micromanipulation and its advantages, Selective animal breeding and their potential. Production and uses of transgenic animals. Animals as a bioreactor for production various chemicals. Stem cells and their application in production of transgenic animals.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links:
https://a.impartus.com/ilc/#/globalsearch?q=transgenic%20animals&page=1&mode=0000000000

UNIT-IV

Animal diseases, diagnosis and Therapy

Bacterial and Viral diseases in animals (Brucellosis, foot and mouth disease, blue tongue disease, rabies and anthrax), RFLP, RAPD and its applications in domestic animals. Molecular diagnostics of pathogens in animals. Biotechnological approaches to vaccine production for animal diseases. Peptide vaccines, Recombinant vaccines, DNA vaccines, antiidotype antibody vaccines.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://www.woah.org/en/what-we-do/animal-health-and-welfare/animal-diseases/

UNIT-V

Applications of Animal Biotechnology, Ethical issues and guidelines

Animal improvement in diary, fishery and poultry. Production of pharmaceutical chemicals, interferons, interleukins, stem cell factors and hormones. Industrial applications: metabolites production, bio control agents, industrially important enzymes. Animal models for research, Ethical issues in using animals for research purpose. CPCSEA guidelines and Institutional Animal Ethical committee (IAEC).

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links:
https://a.impartus.com/ilc/#/globalsearch?q=Animal%20Biotechnology&page=9&mode=0000000000

Textbooks

1. Freshney RI (2005 and 2010) Culture of Animal Cells, 5thEdn, Wiley-Liss.
2. Spier RE and Griffiths JB (1988) Animal Cell Biotechnology, Academic Press.
3. MM Ranga (2013) Animal Biotechnology, Third edition, Agrobios (India).

Reference Books

1. Lodish, Harvey; Berk, Arnold (2016). Molecular cell biology-sixth edition, Macmillan Education

2. Channarayappa (2006) Molecular Biotechnology**:** Principles and Practices. University Press (India) Pvt. Ltd., WorldwideCRC Press.
3. John RW, Masters, (2000) Animal Cell Culture: Practical Approach, 3rdEdn, Oxford.
4. Clynes (1998) Animal Cell Culture Techniques, 1stEdn, Springer.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/102104059

Course Outcome: **(COs):**

On completion of this course student will have improved ability to:-

1. Understand the principles of various cell culture techniques and applications (PO1 & PO5)
2. Apply advanced techniques in the field of cell culture research and development (PO1 & PO5)
3. Impart knowledge on artificial breeding, production and applications of transgenic animals (PO3 & PO-5)
4. Impart knowledge on various diseases of domestic animals, diagnosis and therapy to diseases. (PO1 & PO3)
5. Apply the concepts of cell culture transgenic technology in the field of modern life science. (PO4 & PO5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentations/surprise test (Any two)	10	CO1, CO2, CO3
Quiz	10	CO4, CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4, CO5

TOXICOLOGY AND FORENSIC SCIENCE

Course Code: MBTE231 **Credits:** 4:0:0

Contact hours: 56L

Course Coordinator(s): Dr. Ravikumar Y. S. and Dr. Abhijith S. R

Unit I

Toxicants absorption and genotoxicity

Introduction to toxicology: History and scope of toxicology, Source of toxicants. Classification of toxic agents.Occupational toxicology: Workplace, hazardous exposure, and occupational diseases. Mechanism of toxicity: Toxicant delivery, reaction with the target molecule, cellular dysfunction, inappropriate repair and adaptation. Non target organ toxicity: Chemical carcinogenesis mechanisms of carcinogens. Genetic toxicology mechanisms of genetic alterations. *Teratology:* teratogens, teratogenesis. Cytotoxicity mechanisms of cell death: Apoptosis and Mitochondrial dysfunction,

Pedagogy/Course delivery tools: Chalk and Talk, Power Point Presentation.
Links for drug absorption: https://youtu.be/kkUxUBoM-hM

Unit II

Target organ toxicity and metabolism of toxicants

Toxic effects on liver, kidney, nervous, endocrine, respiratory, immune and reproductive systems. Metabolism of toxicants: Phase I Reactions: Microsomal oxidation Nonmicrosomal oxidations Reduction Reactions, Hydrolysis, Epoxide Hydration. cooxidation. Phase II Reactions: Conjugation reactions, Methyltransferases and Acylation. Reactive Metabolites**:** nature, stability and fate of reactive metabolites, Elimination of Toxicants: renal, hepatic and respiratory elimination

Pedagogy/Course delivery tools: Chalk and Talk, Power Point Presentation.
Links for Metabolism of toxicants: https://youtu.be/01UdzCj6tG0

Unit III

Toxicology Testing

Food toxicology: introduction, safety standards for foods and food ingredients and contaminants. *In Vivo* Toxicology: Testing *of* acute, subchronic and chronic toxicity. *In Vitro testing:* Cell Culture Methods, Ames forward mutation assay, Assessing genotoxicity: mitotic index, chromosomal aberrations, micronucleus assay, cytotoxicity and apoptosis assay. Neurotoxicity testing.

Pedagogy/Course delivery tools: Chalk and Talk, Power Point Presentation.

Links for Toxicity testing: https://youtu.be/tHpJswFTSFY

Unit IV

Forensic Biology

Introduction and scope of Forensic Biology. Botanical evidences: Types, location, collection evaluation and forensic significance of Diatoms, Wood, Pollen grains. Wild Life Forensics: Identification of wild life materials such as skin, bones, nails, horn, teeth, flowers and plants, by conventional and modern methods, Identification of Pug marks of various animals. Forensic Physical Anthropology & Odontology: Definition and significance in forensic science. Importance of bones and teeth in forensic investigation. Forensic Entomology: Significance in forensic science. insects of forensic importance, collection of entomological evidence during forensic investigations. Forensic Microbiology: Types and identification of microbial organisms of forensic significance.

Pedagogy/Course delivery tools: Chalk and Talk, Power Point Presentation.
Links for forensic serology: https://youtu.be/H4oZpOXSVOU and
https://youtu.be/to96vIX5Dug

Unit V

Forensic molecular biology

Blood: Composition and functions, Human Blood groups: Blood group determination from fresh blood, titer, rauleaux formation. Forensic, Characterization of Bloodstains, Stain Patterns of Blood. Semen: Composition, functions and morphology of spermatozoa, Forensic significance, location, collection, evaluation. Body fluids: Forensic significance of other body fluids as Saliva, Sweat and fecal matters, their collection and identification. Hair: Introduction, types, location, collection evaluation and forensic significance of Hair. DNA Profiling: Introduction, History of DNATyping, molecular biology of DNA, variations, polymorphism, methods of DNA Extraction for forensic investigation. DNA typing systems- RFLP analysis, PCR amplifications, sequence polymorphism. Analysis of SNP, YSTR, Mitochondrial DNA, Ancient DNA typing, Forensic Significance of DNA profiling: Applications in disputed paternity cases, child swapping,

Pedagogy/Course delivery tools: Chalk and Talk, Power Point Presentation.
Links for forensic DNA analysis:
https://www.youtube.com/live/98sJQtlltmY?feature=share

Textbooks:

1. Barile FA. - Principles of toxicology testing .CRC Press is an imprint of the Taylor & Francis Group New York, 2008.
2. Hodgson EA - Textbook of Modern Toxicology Third edition John wiley& sons, inc., publication, 2004.
3. Richard L.- Forensic Biology CRC Press 2011

Reference books

1. Osweiler GD. - Toxicology, Wiley-Blackwell Publisher, 1996.
2. Marquardt H. - Toxicology, Academic Press, 1999.
3. Derelanko MJ. - Handbook of toxicology, CRC Press, 2002.

Course Outcomes: On completion of this course student will able to:

1. To describe the general toxicology principles, chemical basis of toxicity carcinogenesis and genotoxicity (PO3)
2. To recognize that toxic outcomes result from interaction between the toxic substance and the metabolic machinery of the organ and identify the damage process, action and metabolism of toxic chemicals. (PO3 & PO4)
3. To describe how toxic chemicals are tested and regulated. (PO1, PO3 & PO4).
4. Distinguish between different types of biological evidences and their significance in forensic investigation. (PO2, PO4 & PO5).
5. Select appropriate blood test and DNA markers in forensic investigation. . (PO2, PO3, PO4 & PO5).

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 and CO2
Internal Test-II	30	CO3,CO4 and CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Quiz/Surprise test	10	CO1, CO2 and CO3
Assignment/Presentation	10	CO4 and CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4, CO5

BIOPROCESS ENGINEERING

Course Code: MBTE232 **Credits:** 4:0:0

Contact Hours: 56L

Course Coordinators: Dr. Bhavya S G & Dr. Chandraprabha M N

UNIT-I

Introduction and Biological Basics to Bioprocess Engineering

Biological systems in bioprocesses: Cell Structure and function, Cell metabolism, Metabolic regulation- metabolic pathway control, cells interaction/senses to extracellular environment. Biotechnology and bioprocess engineering. Steps in bioprocess development, Generalized bioprocess flow sheets. Microbial growth and product formulation, Pure and mixed culture, Logistic equations for microbial growth kinetics models, Unstructured non segregated models and Logistic equations. Bioprocesses: Regulatory Constraints.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://www.youtube.com/watch?v=Z4tc9JdYQmo

UNIT-II

Metabolic Pathways for the Biosynthesis of Industrial Products:

Feedback control system regulated by microorganisms for the synthesis of primary metabolites. Feedback regulatory mechanisms. Auxotrophic mutants in the overproduction of Primary Metabolic Products. Control of the aspartate family of amino acids. Production of amino acids from auxotoph organisms. Mechanisms Enabling Microorganisms to Avoid Overproduction of Primary Metabolic Products Through Enzyme Regulation, Derangement or Bypassing of Regulatory Mechanisms for the Over-production of Primary Metabolites. Regulation of Overproduction in Secondary Metabolites.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://essentialoil.wu.ac.th/wp-content/uploads/2019/07/Processes-for-Overproduction-1.pdf
https://nptel.ac.in/courses/104106106

UNIT-III

Enzyme Kinetics for Bioprocess Reactions

Microbial and enzyme kinetics, multiple substrate and multiple species of fermentation, Mechanistic models for simple and complex enzyme kinetics, Diffusional effects in

immobilized enzyme systems: Diffusion effects in surface bound enzymes on nonporous support material, Diffusion effects in enzymes immobilized in a porous matrix. Electrostatic and steric effects in immobilized enzyme systems. Large scale production of enzymes, Bioreactors used for immobilized cells and enzymes, Medical and industrial utilization of enzymes

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://onlinecourses.nptel.ac.in/noc22_bt09/preview

UNIT-IV

Sterilization Kinetics

Sterilization: concept and methods. Type of Sterilizations, Batch and continuous heat sterilization of Liquid media, Effect of sterilization on quality of nutrients. Thermal death kinetics of microorganisms, Del factor calculations, Del factors during heating, holding and cooling, Methods for evaluating del factor. Estimation of sterilizer efficiency, Continuous heat sterilization of liquids, Sterilization of air: Methods & Mechanism, Design of depth filter and estimation of its efficiency.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://archive.nptel.ac.in/courses/102/106/102106053/

UNIT-V

Bioprocess Scale up, Scale down and Economics

Overview of Bioreactor types and their modes of operations, Scale up concepts, criteria for bioreactors scale up, Various approaches to scale-up including regime analysis, scale-up methods by currently used rules-of-thumb viz. constant P/V, kLa etc., bioprocess control methodologies, product recovery. Scale up criteria for bioreactors based on oxygen transfer, power consumption and impeller tip speed. Scale down models, experimental setup for scale-down experiments. Introduction to Case Studies, Case introduction, Process description, model description, Inventory analysis, Economic assessment, environmental assessment. Typical stages in commercialization of process/ product; Commercial and financial aspects of bioprocessing.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://ami-journals.onlinelibrary.wiley.com/doi/10.1111/1751-7915.12732
https://www.mdpi.com/2227-9717/8/4/436

Text Books:

1. Doran, (2014). Bioprocess Engineering Principles, 2nd Edition, Academic Press
2. M. L Shuler and F. Kargi., (2002). Bioprocess Engineering, 2nd edition, Prentice Hall Inc.
3. Stanbury P F and Whitaker A, (1995). "Principles of Fermentation Technology," 2nd edition, Elsevier.
4. Mansi E M T EL, Bryce C F A, (2003). "Fermentation Microbiology and Biotechnology".Ane Books Publishers and Distributors.

Reference Books:

1. James Bailey, David Ollis, (2017). Biochemical Engineering Fundamentals, 2nd Ed., McGraw Hill Education.
2. Dubasi Govardhana Rao, (2010). Introduction to Biochemical Engineering, Tata McGraw Hill.

Web links and Video Lectures:

1. Principles of techniques in bioprocess https://nptel.ac.in/courses/102106022
2. Introduction to Biochemical and Bioprocess Engineering https://in.coursera.org/lecture/industrial-biotech/introduction-to-biochemical- and-bioprocess-engineering-hoHUU

Course Outcomes (COs):

At the end of the course, Students will have the ability to:

1. Apply the bioprocessing fundamentals for process development. (PO1 & PO4)
2. Assess the effect of transport processes in free and immobilised enzyme systems. (PO3)
3. Apply the sterilization concepts for a bioprocess. (PO4 & PO5)
4. Use scale-up and scale-down considerations for bioprocess intensification. (PO4 & PO5)
5. Understand and explain the development of bioprocess engineering in the industry to support a bio-based economy. (PO1 & PO5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 & CO2
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		

Other Components		
Assignment/Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
Quiz/Surprise Test	10	CO1, CO2, CO3, CO4 & CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4 & CO5

IMMUNOLOGY& IMMUNOTECHNOLOGY

Course Code: MBTE233 **Credits:** 4:0:0

Contact hours: 56L

Course Coordinator(s): Dr. P. Dhamodhar& Dr. Bindu S

UNIT-I

Introduction to Immunity

Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; Cellular and Molecular aspects of the innate immune system-Recognition of pathogens and activation of Toll-like receptors, pathogen recognition receptors (PRR) and pathogen-associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, Structure, Polymorphism and intracellular Trafficking, MHC and immune responsiveness and disease susceptibility.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://onlinecourses.nptel.ac.in/noc23_hs05/preview

UNIT-II

Immune responses generated by B and T lymphocytes

Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B- cell development and activation, generation of B-cell diversity – Mechanism of immunoglobulin – gene arrangement and immunoglobulin superfamily. T-cell development – Generation of TCR diversity; functional T Cell subsets; cell-mediated immune responses, ADCC; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide antigens.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://onlinecourses.nptel.ac.in/noc23_hs05/preview

UNIT-III

Immunological Techniques

Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction;

CMI techniques: lymphoproliferation assay, HLA Typing, mixed lymphocyte reaction, Cell Cycle Analysis, Assays of Cell Death.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://onlinecourses.swayam2.ac.in/cec23_bt13/preview

UNIT-IV

Vaccinology

Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, mRNA based vaccines; peptide vaccines, conjugate vaccines; dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://onlinecourses.swayam2.ac.in/cec23_bt13/preview

UNIT-V

Immunotherapeutics

Antibody Generation: Polyclonal antibodies, Monoclonal antibodies.Antibodyengineering:chimeric, Bispecific Antibodies, Abzymes, humanized antibodies, idiotypic antibodies, monoclonal antibodies: Antibody-drug conjugates (ADCs), radiolabeled antibodies, immunotoxins,cell based therapeutics, Cancer immunotheraphy and Immunosuprressive therapy – Cytokine therapy, Immunoglobulin therapy: Replacement and immunomodulators.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://onlinecourses.swayam2.ac.in/cec23_bt13/preview

Text Books:

1. Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Owen. (2019)Kuby Immunology, 8th Edition, Macmillan Education, New York.
2. Abbas, A.K., Lichtman, A.H. and Pober, J.S. (2017)Cellular and Molecular Immunology, 9thEdition, Elsevier.

Reference Books:

1. Peter J. Delves., Seamus J. Martin., Dennis R. Burton., Ivan M. Roitt. (2017) Essential Immunology, 13thEdition Wiley -Blackwell.

2. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). Janeway's Immunobiology. New York: Garland Science.

Web links and Video Lectures (e-Resources):

1. https://onlinecourses.nptel.ac.in/noc23_hs05/preview
2. https://onlinecourses.swayam2.ac.in/cec23_bt13/preview

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Describe the functions of the immune system and its components (PO1, PO3 & PO4)
2. Differentiate the immune responses generated by B and T lymphocytes (PO1, PO3 & PO4)
3. Apply the immunological techniques for diagnosis of diseases (PO3, PO4 & PO5)
4. Comprehend the principle and function of vaccines (PO3, PO4 & PO5)
5. Apply the concept and strategies for immunotherapeutics (PO3, PO4 & PO5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1, CO2 & CO3
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation	10	CO1, CO2, CO3
Quiz/Mini Project	10	CO4 & CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4 & CO5

BIOTECHNOLOGY ENTREPRENEURSHIP

Course Code: MBTE241 **Credits:** 4:0:0

Contact Hours: 56L

Course Coordinators: Dr. T P Krishna Murthy & Dr. Chandraprabha M N

UNIT-I

Understanding Biotechnology Entrepreneurship and Industry

Significance of biotechnology entrepreneur- Integration of science and business-Biotechnology entrepreneurship versus general entrepreneurship-Entrepreneurship and intrapreneurship- Biotechnology entrepreneur, manager, and leader-essential biotechnology entrepreneurial characteristics-Backgrounds of biotechnology entrepreneurs-Driving forces behind a biotech entrepreneur's decisions-Learning from "failure-risks of joining a biotechnology company-Importance of understanding business and finance-raising capital-Managing the uncertainty of biotechnology-Biotechnology entrepreneur's stories- Biotechnology cluster, inhibitors of biotechnology cluster growth, public policy environment for biotech innovation.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://www.edx.org/course/the-science-and-business-of-biotechnology

UNIT-II

Human Capital and Innovative Technology Component

Building, Managing, and Motivating Great Teams: Fundamentals of entrepreneurial process related to teams, key questions to ask when building the team—the academic perspective, understanding factors that motivate teams-Building human relationship networks: Purposeful networking expands limited resources, a roadmap to creating purposeful relationships, boards of advisors and directors can help accelerate company success, human networks lead to mentoring, personal traits and characteristics-Mentorship: why you need a team of mentors to be successful?-Understanding biotechnology product sectors-technology opportunities: evaluating the idea-understanding biotechnology business models and managing risk-directing your technology toward a market problem.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://www.edx.org/course/entrepreneurship-101-who-is-your-customer?

UNIT-III

Emerging Biotechnology Enterprise

Company formation, ownership structure, and securities issues: Translation of academic research to products for the public good, advantages for a biotech start-up to work with the national institutes of health and universities-Licensing the technology: biotechnology commercialization strategies using university and federal labs-Intellectual property protection strategies for biotechnology innovations.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://www.edx.org/course/how-to-start-a-biotech-venture

Unit-IV

Financial Capital Component

Sources of capital and investor motivations-How investors really make decisions? - Securing angel capital and understanding how angel networks operate- Understanding and securing venture capital- Financial ramifications of funding a biotechnology venture- business plan and presentation- Investor presentations.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://www.edx.org/course/the-science-and-business-of-biotechnology

UNIT-V

Biotechnology Product and Market Development

Therapeutic drug development and human clinical trials-Integrating diagnostic products into the drug development workflow-Development and commercialization of medical devices-Commercialization and applications of agricultural biotechnology- Artificial intelligence: emerging applications in biotechnology and pharma-biomanufacturing of biotechnology products-Biotechnology product coverage, coding, and reimbursement strategies-Public relations strategies to support biotechnology business goals-Company growth stages and the value of corporate culture-Biotechnology business development -common biotechnology entrepreneur mistakes and how to avoid them.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://www.edx.org/course/financing-biotech-innovation

Text Books:

1. Shimasaki, C. (Ed.). (2020). Biotechnology Entrepreneurship: Leading, Managing and Commercializing Innovative Technologies. Academic Press.

1. Matei, F., & Zirra, D. (Eds.). (2019). Introduction to Biotech Entrepreneurship: From Idea to Business: A European Perspective. Springer.
2. Allen, K. (2023). Entrepreneurship for dummies. John Wiley & Sons.

Reference Books:

1. Agarwal, S., Kumari, S., & Khan, S. (Eds.). (2021). Bioentrepreneurship and Transferring Technology Into Product Development. IGI Global.
2. Poonam Ghandhi. (2022). Entrepreneurship. VK Global Publications Pvt Ltd.
3. Newman, A., North-Samardzic, A., Bedarkar, M., &Brahmankar, Y. (2021). Entrepreneurship in India. Routledge.
4. Kumar, A. (2012). Entrepreneurship: Creating and leading an entrepreneurial organization. Pearson Education India.
5. Kennard, M. (2021). Innovation and Entrepreneurship, 1st Edition, Routledge.
6. Neck, H. M., Neck, C. P., & Murray, E. L. (2019). Entrepreneurship: The practice and mindset. Sage Publications.

Web links and Video Lectures (e-Resources):

1. Entrepreneurship Specialization: https://www.coursera.org/specializations/wharton-entrepreneurship
2. The entrepreneur's guide for beginners: https://www.coursera.org/learn/entrepreneur-guide-beginners
3. Entrepreneurship in Emerging Economies: https://www.edx.org/course/entrepreneurship-in-emerging-economies
4. Technology Entrepreneurship: Lab to Market: https://www.edx.org/course/technology-entrepreneurship-lab-to-market
5. Understanding Incubation and Entrepreneurship: https://nptel.ac.in/courses/107101092
6. Entrepreneurship: https://nptel.ac.in/courses/110106141
7. Entrepreneurship Essentials: https://nptel.ac.in/courses/127105007
8. Innovation, Business Models and Entrepreneurship: https://nptel.ac.in/courses/110107094

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Understand the entrepreneurship and successful entrepreneurs in the biotechnology and allied sciences (PO1, PO2 & PO3).
2. Apply the principles of human resource management to building successful a biotechnology company (PO1, PO2 & PO3).

3. Acquire the knowledge of ownership and collaborative strategies to build a sustainable biotechnology innovation (PO1, PO2 & PO3).
4. Understand the mindset of investors and develop policies to acquire funding for the start-up (PO1, PO2 & PO3).
5. 5. To explore the product development and market strategies of biotechnology & biopharmaceutical products (PO1, PO2 & PO3).

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 & CO2
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
Quiz/Surprise Test	10	CO1, CO2, CO3, CO4 & CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4 & CO5

BIOENERGY AND BIOFUELS TECHNOLOGY

Course Code: MBTE242 **Credits:** 4:0:0

Contact Hours: 56L

Course Coordinators: Dr. Priyadarshini Dey and Dr. T P Krishna Murthy

UNIT-I

Biomass, Bio-Energy and Bio-Refinery

Biomass Properties and types-Conventional versus renewable energy resources. Greenhouse Gas Emissions calculations. **Biomass constituents**: at molecular level, at chemical level, energy properties. **Biomass typologies**: Generations of biofuels. Lignocellulosic, starchy, sugary, oilseeds, OFMSW, sewage sludge, manure. **Biofuels**: liquid (biodiesel, bioethanol), gaseous (syngas, biogas), solid (charcoal and biochar). **Biomass conversion: Physical conversion:** Dewatering, drying, size reduction, steam explosion, densification, pelleting, chipping, oil extraction. **Chemical conversion:** Oil trans-esterification (biodiesel production). Hydrolysis. **Biochemical conversion:** Anaerobic digestion (biogas production from organic waste and wastewater). Fermentation (bioethanol production). Omics for biofuel production. Introduction to Internal combustion engine.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
*Link:*Biomass Conversion and Biorefinery

UNIT-II

Chemical Engineering Tools for Analysis and Design of Energy Processes

Reaction stoichiometry. Reaction kinetics. Reaction thermodynamics. Reactors. Process analysis and design. **Biomass conversion:** Thermochemical conversion: pyrolysis, gasification, and liquefaction.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Link: Gasification and Pyrolysis

UNIT-III

Liquid Biofuels

Conventional Petrol. **Feedstock Production:** Sugar crops, Starch crops, Cellulosic crops. Properties of Bioethanol and biobutanol. **Bioethanol and biobutanol Production:** Sugar-to-Ethanol Process, Starch-to-Ethanol Process, Cellulose-to-Ethanol Process, Distillation and Dehydration Process. Pre-treatment processes and

fermentation process. Fermenter design for bio alcohol production and types of fermenters. **Technology Applications for Bioethanol:** Spark Ignition Engines. **Conventional Diesel**. **Feedstock Production:** Oilseed Crops, Animal Fats. Properties and Use of Lipid Biofuels: Properties of Pure Plant Oil (PPO), Properties of Biodiesel. **Biodiesel production:** Oil Extraction, Oil Refining, Blending, preheating, Transesterification and emulsification. Biodiesel production by using algae. Scale up of biodiesel production. Technology Applications for Lipid Biofuels: Compression Ignition Engines.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Link: Biodiesel purification, fuel properties

UNIT-IV

Gaseous and Solid Biofuels

Conventional gaseous fuels (Natural gas and LPG). Production methods of Biogas. Feedstock Production. Biomethane Production: Digestion Process, Digester Types, Biogas purification. Properties and Use of Biomethane. Biohydrogen: Biohydrogen Processing, Use of Biohydrogen. Microbial fuel cell. Carbonization of biomass: Biochar production.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Link: Biohydrogen production, metabolics, microorganisms

UNIT-V

Waste materials as source of Biofuels and life cycle assessment

Biofuels from different wastes (wastewater & biomass) as sources of biofuels. Life cycle assessment of various biofuels by OpenLCA software. Calculate the biofuel cost benefit ratios for various biofuels. Economic and social impact of biofuels. Status of biofuel production in India and World.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Link: Techno-economic evaluation

Text Books:

1. Yebo Li, Samir Kumar Khanal (2016). Bioenergy: Principles and Applications,1st Edition Wiley-Blackwell Publications.
2. Love, J., & Bryant, J. A. (Eds.). (2017). Biofuels and bioenergy. John Wiley & Sons.

Reference Books:

1.Sterling MacMillan (2017). Bioenergy: Principles, Technology and Applications, Larsen and Keller Education

2.Nigel G Halford (2015). An Introduction to Bioenergy, Rothamsted Research, UK

Web links and Video Lectures (e-Resources):

Coursera lecture on biofuels

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Identify the biofuel sources to use as an alternative energy to fossil fuel (PO2).
2. Optimize biofuel production and standardize the process to convert raw material to biochar (PO4).
3. Standardize the process to convert raw material into bioethanol, biobutanol and biodiesel production (PO4).
4. Standardize the process of conversion to biogas and biohydrogen (PO4).
5. Exploring different wastewater/waste materials as different biofuel sources and study various parameters to meet the national and international standards and work out economic feasibility of different energy sources (PO5).

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 & CO2
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
Quiz/Surprise Test	10	CO1, CO2, CO3, CO4 & CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4 & CO5

STEM CELL TECHNOLOGY AND REGENERATIVE MEDICINE

Course Code: MBTE243 **Credits**: 4:0:0

Contact Hours: 56L

Course Coordinators: Dr Prabha M

UNIT-I

An Introduction to Stem Cells types and Technology

Unique properties of stem cells: Stem cell Potency and classification, Adult Stem Cells, Embryonic Stem Cells, Induced Pluripotent Stem Cells, Hematopoietic Stem Cells and differentiation, Mesenchymal stem cells, Neural stem cells. Stem cell markers and Isolation of stem cells, Characterization techniques, Translational technologies, Tissue engineering: Functional characterization.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links:
https://www.karger.com/Article/Fulltext/345615
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1129084/

UNIT-II

Embryonic Stem Cells and Induced Pluripotent Stem Cells

Culturing of embryos: *In vitro* fertilization, ESC isolation and growing ES cells in lab Identification and characterization of human ES cells, Cloning and controlled differentiation of human embryonic stem cells. Applications of Embryonic stem cells. Stem cell Engineering: Stem cell specific transcription factors - Induced pluripotent cells. IPS Cells as Experimental Models of Neurodegenerative Disorders: use of them as disease modelling platform.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links:
https://www.oulu.fi/spareparts/ebook_topics_in_t_e_vol4/abstracts/bajada.pdf
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4104807/

UNIT-III

Hematopoietic Stem Cells diseases and Adult Stem Cells Applications

Classification and manifestation of hemopoietic stem cell disorders, plastic hemopoietic stem cell disorders, Cord blood cells, Somatic stem cells, test for identification of adult stem cells, adult stem cell differentiation, Trans differentiation, plasticity-different types of adult stem cells: liver stem cells, skeletal muscle stem cells, bone marrow derived stem cells. Adult stem cells biomedical applications.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1129084/
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1698791/

UNIT-IV

Mesenchymal stem cells and Therapeutic Application of Stem Cells:

Mesenchymal stem cells: cell biology to clinical progress, Applications in medicine and different disease models. Potential of stem cell therapy for various diseases and Molecular Therapeutic applications– Diabetes, Heart disease, Burns and Skin ulcers. High throughput screening of mesenchymal stem cell lines using deep learning, Neurological disorder: Parkinson disease, Alzheimer's disease and spinal cord injuries.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links:
https://nptel.ac.in/courses/102106036
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6721852/
https://www.nature.com/articles/s41392-022-01134-4

UNIT 5

Stem Cells Engineering in Regenerative Medicine

Practice of regenerative medicine: Tissue engineering application–production of complete human organ: kidney, eyes, heart, brain, skin, bone, muscle, pancreas and liver. Induced pluripotent stem cell and its application in regenerative medicine. Tissue Regeneration Driven by Growth Hormones, novel drug testing and implantation studies. Bio banking of stem cells and the ethical considerations in regenerative medicine.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links:
https://www.oulu.fi/spareparts/ebook_topics_in_t_e_vol4/abstracts/bajada.pdf
https://www.sathyabama.ac.in/sites/default/files/course-material/2020-10/UNIT-4_17.pdf
https://nptel.ac.in/courses/102106081

Text Books:

1. Robert Lanza (2009). "Essentials of Stem Cell Biology" Elsevier publications.
2. FirdosAlam Khan (2021) Advances in Application of Stem Cells: From Bench to Clinics Springer publications.

3. Alain A. Vertes, Nasib Qureshi , Arnold I. Caplan , Lee E. Babiss (2015) Stem Cells in Regenerative Medicine: Science, Regulation and Business Strategies, Wiley .

References:

1. Christine Mummery, Anja van de Stolpe, Bernard Roelen, Hans Clevers. (2021) Stem Cells Scientific Facts and Fiction, Elsevier publications.
2. Lucas G. Chase, Mohan C. Vemuri (2013). Mesenchymal Stem Cell Therapy. Springer
3. D.C. Linch (2010) Haemopoietic stem cell disorders. oxford Academic publications.
4. Kursad and Turksen (2002) Embryonic Stem cells by. Humana Press.
5. KursadTurksen (2014) Adult Stem Cells. springer publications.
6. Charles Durand, Sorbonne Université, France Pierre Charbord, Inserm, France. (2021) Stem Cell Biology and Regenerative Medicine, Second edition River Publishers Series in Biotechnology and Medical Research.

Web links and Video Lectures (e-Resources):

1. https://www.sastra.edu/nptel/index.php/9-uncategorised
2. https://ocw.mit.edu/courses/hst-535-principles-and-practice-of-tissue-engineering-fall-2004/pages/lecture-notes/
3. https://nptel.ac.in/courses/102106036

Course outcomes (COs):

After completing the course, the student will be able to

1. Understand the unique properties of stem cell types and Characterization techniques for their function. (PO1, PO4 & PO5)
2. Demonstrate a scientific approach -stem cell engineering and induced pluripotent stem cells as experimental disease models. (PO1, PO3, PO4 & PO5)
3. Classify and Manifest of hemopoietic stem cell disorders and adult stem cell types for biomedical applications. (PO3, PO4 & PO5)
4. Design mesenchymal stem cells as potential therapeutic strategy for the various organ diseases. (PO3, PO4 & PO5)
5. Apply tissue engineering in regenerative medicine and to study the regulatory issues for the clinical applications. (PO3, PO4 & PO5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation	10	CO1, CO2 & CO3
Quiz/Mini Project write up	10	CO4 and CO5
Semester End Examination:	50	CO1, CO2, CO3, CO4 & CO5

QUALITY CONTROL MANAGEMENT

Course Code: MBTE251 **Credits:** 4:0:0

Contact Hours:56 L

Course Coordinators: Dr Divyashri G & Dr Chandra Prabha MN

UNIT-I

Essentials of quality control

Preparations - buffer, solvents, solutions and microbial media for running bio-analytical quality tests, assays to carry out quality control procedures on biopharmaceutical products. Concepts of pharmacopeia like BP, USP, EP and other applicable guidelines such as WHO, ICH and EMEA, etc., statistical tools and software like combistats, safe handling of infectious materials like cultures, strains and seed strains, procedures for handling infectious spillage control, GLP/GMP, biochemical analysis of proteins, bio analytical and microbiological methods, working of instruments/apparatus/equipment, biological assays, application of various analytical techniques such as HPLC, capillary electrophoresis including icIEF, FTIR, Circular Dichroism, UV and Fluorescence spectroscopy, ELISAs, enzyme assays and other applicable methods for the testing of biopharmaceuticals, application of microbiological techniques such as air monitoring, water testing, surface monitoring, microbial monitoring, biosafety levels and biosafety hazards.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation

Links for topic:

https://www.who.int/docs/default-source/medicines/norms-and-standards/guidelines/quality-control/trs957-annex1-goodpractices-harmaceuticalqualitycontrol-laboratories.pdf?sfvrsn=ca0c211c_0

https://biotech.co.in/sites/default/files/Quality%20Control%20Biologist.pdf

UNIT-II

Quality Assurance

Quality checks - quality assurance samples, master sample, internal controls, statistical analysis of test data, techniques and concepts of statistical quality control and statistical process control, non-conformities. Operational aspects – calibration, accuracy checks of quality control equipment like stability chambers and BOD incubators, HPLC, gas chromatography, photoflourometer, etc., application softwares used in quality analysis.

Pedagogy/Course delivery tools: Power point presentation

Links for topic:

https://cpwd.gov.in/Publication/Quality_Assurance_Manual_2022.pdf

https://nhorton.people.amherst.edu/ips9/IPS_09_Ch17.pdf

Unit-III

Safety, Security and Interpersonal Skills at workplace

Different types of occupational health hazards, knowledge of chemical substances, characteristics & safety measures, use of safety gears, masks, gloves & accessories, evacuation procedures for workers & visitors. Health, safety & security issues – types (illness, fire accidents), company policies and procedures, When and how to report, summon medical assistance & emergency services. Understand work output requirements, company rules, guidelines & policies related to the process flow, identifying and reporting issues requiring intervention, delivery of quality work on time & report any anticipated reasons for the delay, importance of team work, resolution of conflicts, multi-tasking, training the team members, knowledge of project management.

Pedagogy/Course delivery tools: Power point presentation

Links for topic:

ttps://blog.vantagecircle.com/interpersonal-skills/

https://www.pfizer.com/about/responsibility/health-safety

Unit-IV

Clean work station

Cleaning the work area and equipments, materials and equipments required for cleaning, adequate ventilation for the work area, personal protective equipments, dealing with accidental damage, procuring and storing housekeeping equipment and supplies, disposal of wastes, maintain schedules and records for housekeeping.

Pedagogy/Course delivery tools: Power point presentation

Links for topic:

https://www.pharmaguideline.com/2008/04/sop-for-laminar-air-flow-workstation.html

https://grantek.com/clean-in-place-cip-in-pharmaceutical-manufacturing/

https://www.merckmillipore.com/IN/en/products/biopharmaceutical-manufacturing/upstream-processing/cleaning-in-place/K..b.qB.6nMAAAFA19FkiQpx,nav?ReferrerURL=https%3A%2F%2Fwww.google.com%2F

Unit-V

Reporting and documentation in quality

Reporting – company procedures, escalation matrix for reporting identified issues - defects, problem, incidents, quality issues and test results, feedback to production manager and R&D staff. Documentation – procedures and good documentation practices, offline and online mode, accuracy, details, controlled document files and test records, regulatory and compliance requirements, inspection - procedures, protocols and checklists, inspection reports.

Pedagogy/Course delivery tools: Power point presentation

Links for topic:

https://www.linkedin.com/pulse/importance-documentation-pharmaceutical-industry-innovative-appz

https://tabraizullah.files.wordpress.com/2020/02/document-maintenance-in-pharmaceutical-industry.pdf

https://www.pharmatutor.org/articles/good-documentation-practice-in-pharmaceuticals

Text Books:

1. El-Mansi, E. M. T., Bryce, C. F., Allman, A. R., &Demain, A. L. (2018) Fermentation Microbiology and Biotechnology. 4th Edition, CRC press.
2. Huynh-Ba, K. (Ed.). (2009). Handbook of stability testing in pharmaceutical development: regulations, methodologies, and best practices (pp. 21-41). New York, NY, USA: springer.
3. Dheyongera, P. (2011). Regulatory affairs training: are we doing enough? in-site. SA Pharmaceutical Journal, 78(10), 38-39.

Reference Books:

1. Mitra, A. (2016). Fundamentals of quality control and improvement. John Wiley & Sons.
2. Aft, L. S. (2018). Fundamentals of industrial quality control. CRC Press.
3. McGraw, M. J., & Haws Jr, T. F. (Eds.). (2010). Principles of good clinical practice. Pharmaceutical Press.

Course Outcomes (COs):

At the end of the course, Students will be able:

1. Course outcome 1: To understand the overview of quality control aspects in biopharmaceutical industry (PO1 & PO2)
2. Course outcome 2: To understand the scope of quality assurance certifications applicable to pharmaceutical industries (PO1 & PO3)

3. Course outcome 3: To understand work output requirements, company rules, guidelines & policies related to the process flow (PO2 & PO4)
4. Course outcome 4: To understand the importance of implementing and complying with facility and equipment cleaning procedures (PO1)
5. Course outcome 5: To appreciate the importance of documentation (PO2)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1, CO2
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Presentations/Group Discussions/Surprise Test	10	CO1, CO2, CO3, CO4 & CO5
Quiz	10	CO1, CO2, CO3, CO4 & CO5
Semester End Examination:	50	CO1, CO2, CO3, CO4 & CO5

METABOLIC ENGINEERING

Course Code: MBTE252 **Credits:** 4:0:0

Contact Hours: 56L

Course Coordinators: Dr. T P Krishna Murthy & Dr. Chandraprabha M N

UNIT-I

Cellular Metabolism

Solute transport processes in the cell- transporter classification system- catabolism and metabolic fuelling: thermodynamics of fuelling processes, products of fuelling processes, redox potentials and mobile electron carriers-biosynthesis of cellular building blocks-polymerization of building blocks to macromolecules-rare metabolic conversions-transcriptional regulation of metabolism.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: Biochemical Principles of Energy Metabolism
https://www.coursera.org/learn/energy-metabolism

UNIT-II

Balances and Reaction Models

Growth nutrients and diversity- rates and mass balances-biomass specific conversion rates-mathematical models for the batch experiment from mass balances and q-based kinetics-data reconciliation and error detection peter-black box models for growth and product formation-metabolic models for growth and product formation-thermodynamic description of microbial growth and product formation.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Link: Material and Energy Balances
https://nptel.ac.in/courses/102/106/102106069/

UNIT-III

Modelling in Metabolic Engineering

Metabolic flux analysis-metabolic flux quantification methods-metabolic control analysis: definitions and structure of metabolic reaction networks, mathematical models of metabolic-structure and flux analysis of metabolic networks-constraint based genome-scale models of cellular metabolism-multiscale modelling of metabolic regulation-validation of metabolic models.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation

Link: A comprehensive metabolic map for production of bio-based chemicals https://www.nature.com/articles/s41929-018-0212-4

UNIT-IV

Tools in Metabolic Engineering

Improving Protein Functions by Directed Evolution-Engineering DNA and RNA Regulatory Regions through Random Mutagenesis and Screening-Evolving Pathways and Genomes for the Production of Natural and Novel Compounds-Models Predicting Optimized Strategies for Protein Evolution-Application of Emerging Technologies to Metabolic Engineering: Genome-Wide Technologies: DNA Microarrays, Phenotypic Microarrays, and Proteomics, Monitoring and Measuring the Metabolome- In Silico Models for Metabolic Systems Engineering.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Link: Tools and Strategies of Metabolic Engineering
https://www.sciencedirect.com/journal/metabolic-engineering/vol/63/suppl/C

UNIT-V

Hosts for Metabolic Engineering & Applications of Metabolic Engineering

Escherichia coli, Yeast, Bacillus subtilis, Streptomyces, Mammalian Cells as host for metabolic engineering studies. Energy and Cofactor Issues in Fermentation and Oxyfunctionalization- Microbial Biosynthesis of Fine Chemicals, Applications of Metabolic Engineering for Natural Drug Discovery-Metabolic Engineering for Alternative Fuels.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Link: Metabolic Engineering Host Organism Special Issue
https://www.sciencedirect.com/journal/metabolic-engineering/vol/50/suppl/C
Metabolic Engineering Products Issue
https://www.sciencedirect.com/journal/metabolic-engineering/vol/58/suppl/C

Text Books:

1. George Stephanopoulos Aristos Aristidou, Jens Nielsen (1998). Metabolic Engineering: Principles and Methodologies, 1st edition, Academic Press.
2. Lee, S. Y., Nielsen, J., & Stephanopoulos, G. (Eds.). (2021). Metabolic Engineering: Concepts and Applications.

Reference Books:

1. Christina D. Smolke (2009), The Metabolic Pathway Engineering Handbook: Fundamentals, 1st edition, CRC Press.
2. Christina D. Smolke (2009), The Metabolic Pathway Engineering Handbook: Tools and Applications, 1st edition, CRC Press.
3. S Y Lee and E T Papoutsakis (1999). Metabolic Engineering, Marcel Dekker, NewYork, 1999.
4. Néstor V Torres, Eberhard O. Voit (2002). Pathway Analysis and Optimization in Metabolic Engineering, 1st Edition, Cambridge University Press.
5. Stephen Van Dien (2016) Metabolic Engineering for Bioprocess Commercialization, Springer International.

Web links and Video Lectures (e-Resources):

1. Metabolic Engineering: https://nptel.ac.in/courses/102/105/102105086/
2. Introduction to Systems Biology: https://www.coursera.org/learn/systems-biology
3. Experimental Methods in Systems Biology: https://www.coursera.org/learn/experimental-methods
4. Network Analysis in Systems Biology: https://www.coursera.org/learn/network-biology
5. Dynamical Modeling Methods for Systems Biology: https://www.coursera.org/learn/dynamical-modeling

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Understand the central metabolic reactions and regulations in cellular metabolism. (PO- 3, 4, 5)
2. Describe the various models for the regulation of metabolic pathways at different levels. (PO-3, 4, 5)
3. Analyze the metabolic flux for real-time industrial applications. (PO-3, 4, 5)
4. Utilize various scientific tools for engineering microbial pathways. (PO-3, 4, 5)
5. Development of effective solutions for various industrial and environmental problems using metabolic engineering. (PO-3, 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 & CO2
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
Quiz/Surprise Test/Tutorial Test	10	CO1, CO2, CO3, CO4 & CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4 & CO5

ADVANCES IN CANCER BIOLOGY

Course Code: MBTE253 **Credits:** 4:0:0

Contact Hours: 56L

Course Coordinators: Dr. Abhijith S.R

UNIT-I

Fundamentals of Cancer

Introduction to cancer, Classification of tumors, Cancer epidemiology, Etiology of cancer: Tobacco associated with cancer development, viruses and cancer (RNA and DNA viruses), Bacteria, Hormones and cancer, Cancer susceptibility syndromes, inflammation and cancer, Chemical & physical carcinogens, carcinogenesis, diet and cancer. Cancer stem cells.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
*Links for topic:*https://a.impartus.com/ilc/#/globalsearch?q=cancer&page=5&mode=0000000000

UNIT-II

Molecular Biology and Genetics of Cancer

Oncogenes, Tumour suppressor genes, Growth factors and growth factor receptors, Signalling pathways, Cell cycle regulation, Genomic instability, Programmed cell death, Autophagy, Role of telomeres and Senescence, Gene regulation and epigenetics. Tumor micro environment and progression of cancer. Cellular energetics and Warburg effect.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links for topic:
https://a.impartus.com/ilc/#/globalsearch?q=cancer%20biology&page=1&mode=0000000000

UNIT-III

Invasion and Metastasis

Epithelial to Mesenchymal transition (EMT), Circulating Tumour cells, Angiogenesis and its implication in tumour progression, Escape from immune surveillance by cancer cells, evolution and pathogenesis of metastasis, Models for metastasis, Role of extracellular matrix and CAMs in invasion, Hallmarks of Cancer**.**

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links for topic: https://www.youtube.com/watch?v=xhroqGbLTuk

UNIT-IV

Cancer Diagnosis and Therapy

Detection of cancers: Prediction of aggressiveness of cancers, CT, MRI, PET. Cancer biomarkers and prognostic panels, Chemotherapy, Radiation therapy, targeted therapies based on genetic profiles, Principles of Immunotherapy, Monoclonal antibodies and cancer treatment, CAR-T cells, Death receptors and activation, Stem cell based therapies, Gene therapy, Targeted drug delivery, Natural Products as a platform for anti-cancer drug development. Challenges in treatment of cancer.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
*Links for topic:*https://a.impartus.com/ilc/#/globalsearch?q=cancer%20biology&page=2&mode=0000000000

UNIT-V

Techniques in Cancer Research

Cell culture techniques, Proliferation assays, Transformation and immortalization, Properties of transformed cells, Colony formation assays, Migration assay, Invasion assay, Cell cycle analysis and apoptosis by flowcytometry, LDH assay, ROS assay, Immunoassays to detect specific antigens, Gene silencing / over expression, Animal models for cancer.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links for topic:
https://nptel.ac.in/courses/102104059

Text Books

5. Robert Weinberg (2014). The Biology of Cancer. Second edition, Garland Science.
6. Lodish Harvey and Berk Arnold (2016). Molecular cell biology. Sixth edition, Macmillan Education
7. McDonald, F et al., (2004). “Molecular Biology of Cancer”. Second Edition. Taylor & Francis

Reference Books/articles

1. King, Roger J B; Robins, Mike,W (2006). Cancer Biology, Pearson Education Asia.

2. Langdon, Simon P (2004). Cancer cell culture: Methods and protocols, Humana Press, New Jersey.
3. Terrian, David M (2003). Cancer cell signalling: Methods and protocols Publisher, Humana Press.
4. Baronzio Gianfranco; FiorentiniGiammaria (2009). Cancer microenvironment and therapeutic implications: Tumor pathophysiology mechanisms and therapeutic strategies, Springer

Web links and Video Lectures (e-Resources):

1.https://in.coursera.org/learn/cancer
2.https://www.my-mooc.com/en/mooc/introduction-to-the-biology-of-cancer/
3.https://nptel.ac.in/courses/102104059

Course Outcome: **(COs):**

On completion of this course student will have improved ability to:-

1. Understand the fundamental concepts and causes of cancer (PO1, PO3)
2. Impart knowledge on the molecular aspects of cancer, tumour microenvironment and progression of cancer (PO1, PO3).
3. Impart knowledge on Hallmarks of cancer invasion and metastasis (PO1, PO3)
4. Apply the concepts of radiation, chemotherapy and principles of immunology in cancer detection and therapy (PO2, PO4, PO5)
5. Apply the concepts of cell culture techniques in cancer research. (PO2, PO4, PO5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Quiz	10	CO1, CO2, CO3
Assignment/Presentations/Surprise test (Any two)	10	CO4, CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4, CO5

NANOBIOTECHNOLOGY

Course Code: MBTE321 **Credits:** 3:0:0

Contact Hours: 56L

Course Coordinators: Dr. Roshni Ramachandran

UNIT-I

Introduction to Nanotechnology and Nanobiotechnology

History and scope of nanotechnology; role of size in nanomaterials: Properties of nanomaterials- Physical &Chemical properties. Classification of nanoparticles- nano-clusters, nanotubes, nanowires and nanodots. Electronic structure: quantum dots, quantum wires and quantum wells, confinement of electrons energy quantization, Semiconductor nanocrystals, carbon nanotubes, quantum wells.

- Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
- Links: https://archive.nptel.ac.in/courses/118/107/118107015/
- https://in.video.search.yahoo.com/search/video?fr=mcafee&ei=UTF-8&p=introduction+to+nanobiotechnology+videos&vm=r&type=E211IN826G0#id=1&vid=0ba8b5f8711a3a8c651c654c6fe1394e&action=click

UNIT-II

Synthesis of Nanomaterials

Chemical Method: Chemical precipitation and coprecipitation; Metal nanocrystals by reduction, Sol-gel synthesis; Microemulsions or reverse micelles, myle formation; Solvothermal synthesis; Thermolysis routes, Microwave heating synthesis; Sonochemical synthesis; Electrochemical synthesis; Photochemical synthesis, Synthesis in supercritical fluids. Physical Methods: Vapor deposition and different types of epitaxial growth techniques- pulsed laser deposition - Magnetron sputtering - Micro lithography (photolithography, soft lithography, micromachining, e-beam writing, and scanning probe patterning). Biological Methods: Microbial production of inorganic nanoparticles – Magnetosomes. DNA based nanostructures

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://archive.nptel.ac.in/courses/118/107/118107015/
https://in.video.search.yahoo.com/search/video?fr=mcafee&ei=UTF-8&p=synthesis+of+nanomaterials+videos&vm=r&type=E211IN826G0#id=1&vid=48df297ecd1120b9d63cc28352a71f22&action=click

UNIT-III

Characterization of Nanomaterials:

Structural Characterization: X-ray diffraction, Small angle X-ray Scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), **,**Scanning Tunneling Microscopy (STM), Atomic force Microscopy (AFM). Spectroscopic characterizations: application of UV-VIS-IR Raman spectroscopy for analysis of nanomaterials, Surface Characterization: X-ray Photoelectron Spectroscopy (XPS), Auger electron spectroscopy, Low Energy Ion, Scattering Spectroscopy (LEISS), Secondary Ion Mass Spectroscopy (SIMS), Rutherford Backscattering Spectroscopy (RBS). Resonance Methods: Electron Spin Resonance (ESR), Ferromagnetic Resonance (FMR), Nuclear Magnetic Resonance (NMR), Mossbauer Spectroscopy.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://archive.nptel.ac.in/courses/118/107/118107015/
https://in.video.search.yahoo.com/search/video?fr=mcafee&ei=UTF-8&p=characterization+of+nanomaterials+videos&vm=r&type=E211IN826G0#id=2&vid=22d582d3f3844168ae640dd39c86456f&action=click

UNIT-IV

Biological Nanomaterials:

Protein based nanostructures building blocks and templates – Proteins as transducers and amplifiers of biomolecular recognition events – Nanobioelectronic devices and polymer nanocontainers. DNA based nanostructures – Topographic and Electrostatic properties of DNA and proteins – Hybrid conjugates of gold nanoparticles. Biocompatible polymers: liposomes, dendrimers, Chitosan

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links: https://link.springer.com/book/10.1007/978-981-13-9791-2

UNIT-V

Biological Application of Nanotechnology:

Nanoparticles in Therapeutic applications– Drug delivery, imaging and cancer treatment, bone substitutes and dentistry, Implants and Prosthesis, Reconstructive Intervention and Surgery, Nanorobotics in Surgery, Photodynamic Therapy, Neuro-electronic Interfaces, Protein Engineering. Nanotechnology in Agriculture and Food Technology, Biosensors: Principles- DNA based biosensors – Protein based biosensors, Nanosensors in Diagnosis. DNA Templated Electronics, Sequence –specific molecular

lithography, Single Biomolecule. Manipulation for Bioelectronics, DNA as a semiconductor. Environmental issues, toxicity of nanomaterials., ethical issues, the future of nanotechnology in medicine.

Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
Links:https://insights.globalspec.com/article/4717/biological-applications-of-nanoparticles

Textbooks

1. Edelstein A.S, Cammaratra R.C (1996) Nanomaterials: Synthesis, Properties and Applications, Second Edition, CRC PressTaylor and Francis group New York USA
2. Christof M. Niemeyer, Chad A. Mirkin (2004)Nanobiotechnology: Concepts, Applications and Perspectives John Wiley & Sons
3. YubingXie (2012) The Nanobiotechnology Handbook CRC Press Taylor and Francis group New York USA

Reference Books

1. Richard Booker and Earl Boysen (2005) Nanotechnology, Wiley Dreamtech.
2. Chapman & Hall (2002) Nanobiotechnology–Basic Science & Emerging Technologies, CRC Press.
3. Eric K Drexler, Pelerson C, Pergamit G (1993) Unbounding the future. William Marrow and Company
4. Mark Ratner and Daniel Ratner (2005) Nanotechnology. Prentice Hall
5. Murthy DVS (1995) Transducers and instrtumentation. Prentice Hall of India
6. Jing Chung & Larry J. Kricka (2001) Biochip Technology. Harwood academic publishers.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=ebO38bbq0_4
2.https://www.youtube.com/watch?v=ebO38bbq0_4&list=PLbMVogVj5nJTdeiLvuGSB_AE8hloTAHWJ
3. https://www.youtube.com/watch?v=US-8vnKo85E
4. https://pubmed.ncbi.nlm.nih.gov/28393698/
5. https://www.slideshare.net/sumeetsharma32/nanomaterials-in-biomedical-application

Course Outcome: On completion of this course student will have the improved ability to:-

1. Develop an understanding of the fundamental concepts in nanotechnology and different classes of nano-materials. (PO1,4,5)
2. Impart basic knowledge on various synthesis techniques involved in Nanotechnology and characterization. (PO1,4,5)
3. Describe applications of various techniques used in characterization of nanomaterials (PO 4,5)
4. Think of novel, future applications of nanotechnology in biotechnology and for molecular medicine. (PO 4,5)
5. Have knowledge in Applications of Nano-Drug Delivery, Diagnostics and Nanotherapeutics. (PO 4,5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 & CO2
Internal Test-II	30	CO3, CO4 & CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Assignment/Presentation/Mini Project	10	CO1, CO2, CO3, CO4 & CO5
Quiz/Surprise Test	10	CO1, CO2, CO3, CO4 & CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4 & CO5

AI APPLICATIONS IN BIOTECHNOLOGY

Course Code: MBTE322 **Credits:** 4:0:0

Course Coordinator(s): Dr. Samrat K **Contact hours:** 56L

Unit-I
Introduction to AI

Artificial Intelligence: Definition, history, goals and roots of AI, types and components of AI, turning test, techniques and subfields of AI, Heuristics, advantages and disadvantages, types of machine learning and algorithms, liner and generalized liner models, k-Nearest Neighbour algorithm, applications.

Pedagogy/Course delivery tools: : Chalk and talk, PowerPoint Presentation
*Links:*https://nptel.ac.in/courses/112103280

Unit-II
AI in healthcare

Artificial Intelligence management of patients with intracranial neoplasams, Alzheimer's disease detection, cardiovascular disease diagnosis and prognosis, cancer diagnostics and treatment, medical imaging, diagnosis and management of respiratory diseases, infectious diseases, patient care monitoring.

Pedagogy/Course delivery tools: Chalk and talk, PowerPoint Presentation
*Links:*https://www.youtube.com/watch?v=_AoND-VJ4wI

Unit-III
AI in medicine and drug discovery

Introduction and scope of AI in drug discovery, data types and resources, machine learning approaches for target-drug interactions - target identification and validation, lead discovery, lead optimization, evaluating safety and toxicity, drug repurposing, molecular dynamic simulations, AI for assessing side effects of drugs. importance of AI in medicine, disease detection through computationally enabled diagnostics, computer vision and robotics, medical diagnosis, cardiovascular and breast cancer imaging, surgical pathology, dermatology, respiratory disorders, future challenges.

Pedagogy/Course delivery tools: Chalk and talk, PowerPoint Presentation
*Links:*https://www.youtube.com/watch?v=nVfqV0wi9lA
https://www.youtube.com/watch?v=_rrfGTAn7Ck
https://www.youtube.com/watch?v=C3V8PQ-bgIM
https://www.youtube.com/watch?v=hpRWERBWlho

Unit-IV

AI in Agriculture

History of precision agriculture and its global adoption, need and scope of precision agriculture, components, tool and techniques, site specific crop management, variable rate application and variable rate technology, benefits of smart intelligent precision agriculture, applications – soil management, smart irrigation systems, weather forecasting, tackling the labour challenge, crop sowing, crop monitoring systems, plants disease detection, societal and economic impact of AI and ML in intelligent precision agriculture, environmental impact and regulations.

Pedagogy/Course delivery tools: Chalk and talk, PowerPoint Presentation
*Links:*https://nptel.ac.in/courses/126105021

Unit-V

AI in food safety and environment

AI in food safety, improving food quality, role of ML and computer vision in agri-food industry. Introduction to AI and environmental health, AI in pollution control and management, wastewater treatment systems, removal and sensor based detection of contaminants in the aquatic environment, environmental hazard monitoring- detection of pesticides, phenolic compounds, heavy metal ions and pathogenic microorganisms,

Pedagogy/Course delivery tools: Chalk and talk, PowerPoint Presentation
*Links:*https://www.youtube.com/watch?v=bDAEKjYv_eM

Text Books:

1. Oswald Campsites (2020) Artificial intelligence machine learning and deep learning, Mercury Learning and Information LLC.
2. DebmalyaBarh (2020) Artificial intelligence in precision health - From concept to applications, 1stEdn., Academic Press, Elsevier inc.
3. Stephanie Kay Ashenden (2021) The Era of Artificial Intelligence, Machine Learning, and Data Science in the Pharmaceutical Industry, Academic Press.

Reference Books:

1. Adam Bohr and KavehMemarzadeh (2020) Artificial Intelligence in Healthcare, Academic Press, Elsevier inc.
2. NiklasLidstromer and HutanAshrafian (2022) Artificial Intelligence in Medicine, 1stEdn., Springer.

3. Latief Ahmad and Firasath Nabi (2021) AGRICULTURE 5.0 - Artificial Intelligence, IoT and Machine Learning, 1stEdn., CRC Press.
4. Mohsen Asadnia, Amir Razmjou, and Amin Beheshti (2022) - Artificial Intelligence and Data Science in Environmental Sensing, 1stEdn., Academic Press, Elsevier inc.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/106105079
2. https://nptel.ac.in/courses/106105152
3. https://nptel.ac.in/courses/106106226
4. https://nptel.ac.in/courses/106106198
5. https://nptel.ac.in/courses/126105021

Course Outcomes (COs):

At the end of the course, Students will be able to:

1. Understand the basics of artificial intelligence and its importance (PO- 3, 5)
2. Understand the concepts of different methods involved in artificial intelligence for healthcare (PO- 3, 4).
3. Apply the knowledge artificial intelligence in medicine and drug discovery (PO- 4, 5).
4. Analyze the developments of artificial intelligence in agriculture (PO- 4, 5).
5. Understand the impact of artificial intelligence in food safety and environmental applications. (PO- 4, 5)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1, CO2
Internal Test-II	30	CO3, CO4, CO5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Presentation/surprise test	10	CO1, CO2, CO3, CO4, CO5
Quiz	10	CO1, CO2, CO3, CO4, CO5
Semester End Examination:	100	CO1, CO2, CO3, CO4, CO5

INFECTIOUS DISEASES

Course Code: MBTE323 **Credits:** 4:0:0

Contact Hours: 56L

Course Coordinators: Dr Bindu S & Dr Dhamodhar P

UNIT-I

Introduction to Infectious Diseases

Host-pathogen interactions, Host defense mechanisms – Innate immunity – Epithelial surfaces, Recognition of conserved features of pathogens, Complement activation; Adaptive immunity – Antigen presentation, B Lymphocytes and T Lymphocytes. Immune evasion, Nutrition: Prebiotics, Probiotics, and Synbiotics. Neglected tropical diseases, Endemics, Pandemics, Nosocomial infections, Sexually transmitted diseases, Zoonosis and Antimicrobial resistance.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Link: Host-Pathogen Interactions:
https://journals.asm.org/doi/10.1128/iai.68.12.6511-6518.2000

UNIT-II

Bacterial Diseases

Gram-positive bacteria, Gram-negative bacteria, Risk groups of microorganisms, and Biosafety levels as per WHO guidelines. Background, Epidemiology, Transmission, Reservoirs, Pathogenesis, Immune evasion, Symptoms, Diagnosis, Treatment, and Prevention of the following diseases - Bacterial pneumonia, Tetanus, Cholera, Syphilis, Leptospirosis, Bacterial meningitis.

Mycobacterium Diseases – Tuberculosis - Primary, secondary, pulmonary, extra-pulmonary (as per anatomical structures), MDR, and XDR Tuberculosis. Mycobacterium Leprosy, Non-Tuberculous Mycobacteria.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Link: Tuberculosis: https://www.cdc.gov/tb/

UNIT-III

Viral Diseases

Background, Epidemiology, Transmission, Reservoirs, Pathogenesis, Immune evasion, Symptoms, Diagnosis, Treatment and Prevention of the following diseases - Arbo-viral illnesses including Dengue, Chikungunya; Herpes viridae and its infections, Poxviridae; Hepatitis causing viruses; Mumps and Measles viruses; Coronavirus and SARS; Ebola virus associated viral hemorrhagic fever; Polio virus.

Acquired Immunodeficiency Disease Syndrome (AIDS) - History, epidemiology, virology, immunology, disease spectrum including pulmonary, gastroenterological and neurological manifestations of Human Immunodeficiency Virus (HIV), malignancy, treatment guidelines including antiretrovirals, drug toxicity, drug resistance, future planning.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Link: AIDS: https://www.cdc.gov/hiv/basics/index.html

UNIT-IV
Fungal, Protozoan and Helminthic Infections

Superficial mycoses, Subcutaneous mycoses, Deep mycoses including endemic systemic mycoses. Background, Epidemiology, Transmission, Reservoirs, Pathogenesis, Immune evasion, Symptoms, Diagnosis, Treatment and Prevention of the following diseases: Cryptococcosis and Aspergillosis. Amoebiasis and Leishmaniasis. Ascariasis and Schistosomiasis.

Candidiasis – Candida albicans and Non-Candida Albicans Candida (NCAC) – Opportunistic pathogens, Dimorphism, Biofilm, Biofouling of prosthetic material and medical devices and Emerging drug resistance.

Malaria – Disease burden, Lifecycle of Plasmodium, Vector control strategies, Antimalarial drug resistance.

Filariasis - Disease burden, Lifecycle of Filaria, Vector control strategies, Drug resistance.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Link: Malaria: https://www.cdc.gov/parasites/malaria/

UNIT V
Infectious Disease Epidemiology

Environmental factors in infectious diseases. Emerging and re-emerging diseases like Dengue and Ebola. Epidemic alert – Notification and reportable diseases. Recognition of bioterrorism. Control strategies – Levels of prevention and modes of intervention, source reduction, vaccination, integrated vector control strategies, diagnosis and treatment especially with regard to tropical neglected diseases.

International instruments: International health regulations and international disease surveillance. WHO regulations and guidelines. Research in infectious diseases. Knowledge of the Geo–sentinel network and Geographical Information Mapping of

various diseases.

Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
Link: Introduction to Epidemiology
https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section10.html

Text Book:

1. Dennis L Kasper and Anthony S Fauci, (2016) Harrison's Infectious Diseases, 3rd Edition, Mc Graw Hill.
2. Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Owen (2018) Kuby Immunology, 8th Edition, W H Freeman and Co.
3. Patrick R. Murray, Ken S. Rosenthal, Michael A. Pfaller (2020) Medical Microbiology 9th Edition, Elsevier.

Reference Books:

1. Joseph Domachowske (Editor) (2019) Introduction to Clinical Infectious Diseases, 1st Edition, Springer.
2. Timothy P. Endy, Tom Solomon, David R. Hill, Naomi Aronson (2020) Hunter's Tropical Medicine and Emerging Infectious Disease, 10th Edition, Elsevier.
3. John E. Bennett, Raphael Dolin, and Martin J. Blaser (2020) Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases, 9th edition, Elsevier.
4. Merck Manual http://www.merckmanuals.com
5. Merriam-Webster Medical Dictionary https://www.merriam-webster.com/medical

Web links and Video Lectures (e-Resources):

1. Centers for Disease Control and Prevention, www.cdc.gov

Course Outcomes (COs):

At the end of the course, the student will be able to:

1. Understand the complexity and diversity of microbial virulence, and the different strategies pathogens employ for the host manifestation of disease. (PO3)
2. Acquire the necessary understanding and skills w.r.t. host response to pathogens and different ways pathogens evade the immune response in bacterial diseases. (PO3 & PO5)
3. Identify methods of treatment and prevention of infection in viral diseases. (PO3 & PO5)
4. Analyze the disease burden associated with Fungal, Protozoan, and Helminthic infections. (PO3 & PO5)

5. Design and develop surveillance methods as per international agencies to study infectious disease epidemiology, especially in neglected tropical diseases. (PO1 & PO2)

Course Assessment and Evaluation:

Continuous Internal Evaluation: 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1 & CO2
Internal Test-II	30	CO3 & CO4
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Mini Project	10	CO5
Quiz	10	CO1, CO2, CO3, CO4, CO5
Semester-End Examination:	100	CO1, CO2, CO3, CO4, CO5