RAMAIAH
Institute of Technology

CURRICULUM

Outcome Based Education

Academic year 2023 – 2024

DEPARTMENT OF BIOTECHNOLOGY

V & VI SEMESTER B.E

RAMAIAH INSTITUTE OF TECHNOLOGY
(Autonomous Institute, Affiliated to VTU)
Bangalore – 560054.

About the Institute

Dr. M. S. Ramaiah a philanthropist, founded 'Gokula Education Foundation' in 1962 with an objective of serving the 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 11 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 has 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 67% 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. **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. The Institute is a member of DELNET, CMTI and VTU E-Library Consortium. The Institute has a modern auditorium, recording studio, 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, Ramaiah Institute of Technology has achieved 78th rank among 1314 top Engineering Institutions & 23rd Rank among 105 School of Architecture in India for the year 2023.

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 years PG Program, M.Tech in Biotechnology with an intake of 18 students. 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 with a sanctioned budget of Rs. 162.5 Lakhs.

The department has 16 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 department research is focused towards these core areas and funded by national and state funding agencies like DST, KBITS, AICTE, VGST, VTU and RGUHS.

The department faculties and students have publications in Scopus indexed peer-reviewed journals of Elsevier, Taylor and Francis, Springer etc. Faculties have published book chapters and presented their research work in national and international conferences. A sizeable number of students have pursued their higher education at various premier institutes in India and abroad after having qualified GATE, GRE & TOEFL exams. The students undergo internships at various premier institutes in India and abroad. Several students receive the Indian Science Academies Summer Internship every 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, Himalaya Drug Company, Beckman Coulter, Sami Labs, Sartorius AG, Genotypic Technology, Aristogene Biosciences, GangaGen, Connexios Life Sciences, Acquity Labs & Celest Pharma.

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

1. Imparting quality technical education by nurturing a conducive learning environment through continuous improvement and customization.
2. Establishing research clusters in emerging areas in collaboration with globally reputed organizations.
3. 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 a 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, and researchers with a zeal for lifelong learning and a commitment to society.

Programme Educational Objectives (PEOs) of the program

PEO 1: To impart strong foundation in mathematics, basic and engineering sciences contributing to Biotechnology.

PEO 2: To produce graduates who can pursue higher education and research in biotechnology and allied fields.

PEO 3: To produce graduates with an ability to design, develop and implement research projects and apply to solve problems related to areas of biotechnology.

PEO 4: To provide opportunities to students to work in multidisciplinary teams with professional ethics, good communication, leadership skills and commitment to society.

Programme Outcomes (PO): As per NBA guidelines

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSO)

1. To have a thorough grounding in Mathematics, Chemistry and Biology.
2. To be proficient in the principles and practices of advanced biological sciences.
3. To apply engineering principles to biological systems to solve Biotechnology problems.

Semester-wise Credit Breakdown for B.E Degree Curriculum
Batch 2021-25

Semester / Course Category	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Total Credits
Basic Sciences (BSC)	08	08	03	03	--	--	--	--	22
Engineering Sciences (ESC)	11	09	--	--	--	--	--	--	20
Humanities, Social Sciences and Management (HSMC)	--	02	01	01	03	03	--	--	10
Ability Enhancement Course (AEC)	01	01	01	01	01	--	03	--	08
Universal Human Values (UHV)	--	--	02	--	--	--	--	--	02
Professional Core Courses (PCC)	--	--	11	12	11	05	04	--	43
Integrated Professional Core Course (IPCC)	--	--	03	03	03	--	04	--	13
Professional Elective Courses (PEC)	--	--	--	--	03	06	03	--	12
Institutional Open Elective Courses (IOE)	--	--	--	--	--	03	03	--	06
Internship (INT)	--	--	--	02	--	02	--	05	09
Mini Project / Project Work (PW)	--	--	--	--	--	03	03	09	15
Non Credit Mandatory Courses (NCMC)	--	--	Yes	--	Yes	--	--	--	--
Total Credits	20	20	21	22	21	22	20	14	160

SCHEME OF TEACHING V SEMESTER

Sl. No.	Subject Code	Subject	Teaching Department	Category	Credits				Total contact hours /week
					L	T	P	Total	
1	BT51	Biokinetics and Bioreaction Engineering	BT	PCC	2	1	0	3	4
2	BT52	Nanotechnology	BT	IPCC	2	0	1	3	4
3	BT53	Genomics, Proteomics & Bioinformatics	BT	PCC	3	0	0	3	3
4	BT54	Immunology	BT	PCC	3	0	0	3	3
5	BTE55x	Program Elective Course – 1	BT	PEC	3	0	0	3	3
6	BTL56	Bioinformatics Lab	BT	PCC	0	0	1	1	2
7	BTL57	Immunotechnology Lab	BT	PCC	0	0	1	1	2
8	AL58	Research Methodology and Intellectual Property Rights	BT	HSMC	3	0	0	3	3
9	AEC510	Ability Enhancement Course - V	Any Department	AEC	1	0	0	1	1
Total					17	1	3	**21**	**25**
10	HS59	Environmental Studies *	Civil	NCMC	0	0	0	0	1

* Environmental Studies is under the category of NCMC, 1 hour of teaching per week has to be allocated in the timetable.

	Programme Elective Course-1	L	T	P	Total
BTE551	Plant & Agricultural Biotechnology	3	0	0	3
BTE552	Functional Foods & Nutraceuticals	3	0	0	3
BTE553	Pharmaceutical Biotechnology	3	0	0	3
BTE554	Biomedical Engineering	3	0	0	3

Nomenclature: IPCC: Integrated Professional Core Course**, PCC:** Professional Core Course**, HSMC:** Humanity and Social Science & Management Courses**, PEC:** Professional Elective Courses**, AEC–**Ability Enhancement Courses,
NCMC: Non-credit Mandatory Course

L –Lecture, T – Tutorial, P- Practical/ Drawing

Note: BTE55x, where x=1,2,3,4,5

Integrated Professional Core Course (IPCC): Refers to Professional Theory Core Course Integrated with practical of the same course. Credit for IPCC is 03 and its Teaching–Learning hours (L : T : P) can be considered as (2 : 0 : 1). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated only by CIE (no SEE). However, questions from the practical part of IPCC can be included in the SEE question paper.

Professional Elective Courses: A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of engineering. Each group will provide an option to select one course out of five courses. The minimum student's strength for offering professional electives is 10. However, this conditional shall not be applicable to cases where the admission to the program is less than 10.

Innovation/ Societal/ Entrepreneurship based Internship: At the End of fourth Semester four - weeks Summer Internship Shall Be Carried Out – Based On industrial/Govt./NGO/MSME/Rural Internship/Innovation/Entrepreneurship. Credited in fifth Semester. All the students admitted shall have to undergo mandatory internship of 04 weeks during the vacation of IV semester. A Viva-Voce examination shall be conducted during VI semester and the prescribed credit shall be included in VI semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared fail and shall have to complete during subsequent examination after satisfying the internship requirements.

AICTE Activity Points to be earned by students admitted to BE program (For more details refer to Chapter 6, AICTE, Activity Point Program, Model Internship Guidelines):

Every regular student, who is admitted to the 4-year degree program, is required to earn 100 activity points in addition to the total credits earned for the program. Students entering 4 years' degree program through lateral entry are required to earn 75 activity points in addition to the total credits earned for the program. The activity points earned by the student shall be reflected on the students 8^{th} semester grade card. The activities to earn the points can be spread over the duration of the course. However, minimum prescribed duration should be fulfilled. Activity points (non-credit) have no effect on SGPA/CGPA and shall not be considered for vertical progression. Incase student fail to earn the prescribed activity points; 8^{th} semester grade card shall be issued only after earning the required activity Points. Students shall be eligible for the award of degree only after the release of the 8^{th} semester grade card.

The Non-Credit Mandatory Course The students shall attend classes for the course during the semester and complete all formalities of attendance and CIE. In case, any student fails to secure the minimum 40% of the prescribed CIE marks, he/she shall be deemed to have secured **'F'** grade. In such a case, the student has to fulfill the requirements during subsequent semester/s to appear for CIE. This Course shall not be considered for vertical progression, but completion of the course shall be mandatory for the award of the degree.

SCHEME OF TEACHING VI SEMESTER

Sl. No.	Subject Code	Subject	Teaching Department	Category	Credits				Total contact hours /week
					L	T	P	Total	
1	AL61	Management & Entrepreneurship	BT	HSMC	3	0	0	3	3
2	BT62	Upstream & Downstream Bioprocessing	BT	PCC	2	1	0	3	4
3	BTE63x	Program Elective Course – 2	BT	PEC	3	0	0	3	3
4	BTE64x	Program Elective Course – 3	BT	PEC	3	0	0	3	3
5	BTL65	Upstream Bioprocessing Lab	BT	PCC	0	0	1	1	2
6	BTL66	Biokinetics and Bioreaction Engineering Lab	BT	PCC	0	0	1	1	2
7	BTOE01	Biology for Engineers	BT	IOE	3	0	0	3	3
8	BTP67	Mini Project	BT	PW	0	0	3	3	-
9	INT68	Innovation/Societal/Entrepreneurship-based Internship	BT	INT	0	0	2	2	-
Total					**14**	**1**	**7**	**22**	**20**

Programme Elective Course-2	
BTE631	Drug Design & Development
BTE632	Enzyme Engineering & Technology
BTE633	Animal Biotechnology
BTE634	Bioprocess Engineering

Programme Elective Course-3		**L**	**T**	**P**	**Total**
BTE641	Medical Biotechnology	3	0	0	3
BTE642	Food Biotechnology	3	0	0	3
BTE643	Industrial and Environmental Biotechnology	3	0	0	3
BTE644	Biomaterials & Tissue Engineering	3	0	0	3
Institutional Open Elective-1					
BTOE01	Biology for Engineers	3	0	0	3

Nomenclature, PCC: Professional Core Course**, PEC:** Professional Elective Courses, **IOE:** Institutional Open Elective, **PW:** Mini Project, **INT –**Internship

L –Lecture, T – Tutorial, P- Practical/ Drawing

Note: BTE63x , where x=1,2,3,4,5
BTE64x , where x=1,2,3,4,5
BTOE0x*, where x=1,2,..,… continued from previous

L –Lecture, T – Tutorial, P- Practical/ Drawing/ Project work

Professional Elective Courses: A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of engineering. Each group will provide an option to select one course out of five courses. The minimum student's strength for offering professional electives is 10. However, this conditional shall not be applicable to cases where the admission to the program is less than 10.

Institutional Open Elective Courses:
Students belonging to a particular stream of Engineering and Technology are not entitled for the open electives offered by their parent department. However, they can take an elective offered by other departments, provided they satisfy the prerequisite condition, if any.
Registration to open electives shall be documented under the guidance of the Program Coordinator/ Advisor/Mentor.

Selection of an open elective shall not be allowed if,

1. The candidate has studied the same course during the previous semesters of the program.
2. The syllabus content of open electives is similar to that of the Departmental core courses or professional electives.
3. A similar course, under any category, is prescribed in the higher semesters of the program.
4. The minimum students' strength for offering open electives is 10. However, this condition shall not be applicable to cases where the admission to the program is less than 10.

Mini-project work: Mini Project is a laboratory-oriented course which will provide a platform to students to enhance their practical knowledge and skills by the development of small systems/applications.
Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary Mini- project can be assigned to an individual student or to a group having not more than 4 students.

CIE procedure for Mini-project:
(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two faculty members of the Department, one of them being the Guide. The CIE marks awarded for the Mini-project work shall be based on the evaluation of project report, project presentation skill, and question and answer session as per the rubrics defined by the department.
(ii) Interdisciplinary: Continuous Internal Evaluation shall be group-wise at the college level with the participation of all the guides of the

project.

The CIE marks awarded for the Mini-project, shall be based on the evaluation of project report, project presentation skill, and question and answer session as per the rubrics defined by the parent department.

SEE component for Mini-Project: SEE will be conducted by the two examiners appointed by the Institute. SEE marks awarded for the mini project shall be based on the evaluation of project work report, project presentation skill and question and answer session.

Research/Industrial Internship - At the end of sixth / seventh semester (in two cycles to accommodate all the students of the) Research/Industrial Internship shall be carried out – Based on Industrial/Govt./NGO/MSME/Rural Internship/Innovation/Entrepreneurship. All the students admitted shall have to undergo mandatory internship of 24 weeks during the vacation of VI/VII semesters. A Viva-Voce examination shall be conducted during VII semester and the prescribed credit shall be included in VII semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared fail and shall have to complete during subsequent examination after satisfying the internship requirements.

Research internship Students have to take up research internship at Centers of Excellence (CoE) / Study Centers established in the same institute and /or out of the institute at reputed research organization / Institutes. Research internship is basically intended to give you the flavor of current research going on in a particular topic/s. The internships serve this purpose. They help students get familiarized with the field, the skill needed the effort amount and kind of effort required for carrying out research in that field.

Industry internships: Is an extended period of work experience undertaken by /Institute students looking to supplement their degree with professional development. The students are allowed to prepare themselves for the workplace and develop practical skills as well as academic ones. It also helps them learn to overcome unexpected obstacles and successfully navigate organizations, perspectives, and cultures. Dealing with "unexpected contingencies" helps students recognize, appreciate, and adapt to organization realities by tempering knowledge with practical constraints.

AICTE Activity Points to be earned by students admitted to BE program (For more details refer to Chapter 6, AICTE, Activity Point Program, Model Internship Guidelines):

Every regular student, who is admitted to the 4-year degree program, is required to earn 100 activity points in addition to the total credits earned for the program. Students entering 4 years' degree program through lateral entry are required to earn 75 activity points in addition to the total credits earned for the program. The activity points earned by the student shall be reflected on the students 8^{th} semester grade card. The activities to earn the points can be spread over the duration of the course. However, minimum prescribed duration should be fulfilled. Activity points (non-credit) have no effect on SGPA/CGPA and shall not be considered for vertical progression. Incase student fail to earn the prescribed activity points; 8^{th} semester grade card shall be issued only after earning the required activity Points. Students shall be eligible for the award of degree only after the release of the 8^{th} semester grade card.

V Semester

BIOKINETICS AND BIOREACTION ENGINEERING	
Subject Code: BT51	**Credits: 2:1:0**
Prerequisites: Bioprocess Principles and Calculations	**Contact Hours: 28L+14T**
Course Coordinator(s): Dr. Gokulakrishnan M and Dr. Chandraprabha MN	

Course content

UNIT-I

Kinetics of Homogeneous Bioreactions

Basic Concepts of bioreaction and bioprocess engineering, Concentration dependent term of a rate equation. Rate Constant. Representation of elementary reaction and non-elementary reactions, Kinetic Models of Non elementary Reactions, Testing Kinetic Models. Temperature-dependent term of a rate equation: Temperature dependency from Arrhenius law, Constant volume batch reactor, Integral method of analysis of data- first order, second order, zero order reactions.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: http://a.impartus.com/ilc/#/video/id/1012514

UNIT-II

Enzyme Kinetics

General reaction kinetics for biological systems, Methods for investigating the kinetics of Enzyme catalyzed reactions – order of reaction, initial velocity studies. Michaelis-Menten equation, K_M and V_{max}, enzyme inhibition kinetics- competitive, non-competitive and uncompetitive, methods of plotting enzyme kinetics data; Effect of pH and Temperature on enzyme activity.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint Presentation
- Links: http://a.impartus.com/ilc/#/video/id/1010944

UNIT-III

Ideal Bioreactor and bioprocess models

Ideal Batch Reactor, Batch cycle time, Space-Time and Space-Velocity, Mixed flow reactor, plug flow reactor, General features of reactors, Holding time and space time for flow reactors, Growth kinetics quantification- Logistics equation, Models for transient behaviour, Cell growth in continuous culture-Ideal Chemostat.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint Presentation, Videos
- Links: http://a.impartus.com/ilc/#/video/id/1140595

UNIT-IV

Heterogeneous Biocatalysis and Non-Ideal reactors

Immobilized enzyme systems: Methods of Immobilization, Requirements and choice of immobilization methods, Diffusional limitations in immobilized enzyme systems. Various types of reactors for immobilized cell and enzyme systems Non ideal flow, Residence time distribution, step and impulse response, conversion in non-ideal flow reactors.

- Pedagogy/Course delivery tools: Chalk and talk
- Links: http://a.impartus.com/ilc/#/video/id/1190986

UNIT-V

Process Dynamics and Controllers

Biochemical process, Industrial control problem- example, variables of a process, control configuration types, I order system-examples, mercury in glass thermometer, level, mixing. I order system in series, interacting and non-interacting systems. Second order system response, Transfer functions for controllers and final control element, Numericals.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint Presentation, Videos
- Links: http://a.impartus.com/ilc/#/course/267329/703

Text Books:

1. Levenspiel O (2006) Chemical Reaction Engineering, Wiley Eastern, 3rdedn., New Delhi.
2. Kargi and Shuler (2001) Bioprocess Engineering. 2nd edn., Prentice Hall PTR.
3. Pauline Doran (2012) Bioprocess Engineering Principles, 2nd Edition, Academic Press, USA.

Reference Books:

1. Tapobrata Panda. (2011) Bioreactors: Analysis and Design, 1st Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2011.
2. Scott Fogler, H (2009) Elements of Chemical Reaction Engineering, 4thedn., Prentice Hall India Pvt. Ltd.
3. Bailey JE and Ollis DF (2010) Biochemical Engineering Fundamentals, 2nd edn.McGraw- Hill.

4. Charles D. Holland (1990) Fundamentals of Chemical Reaction Engineering, John Wiley and Sons.
5. Donald R. Coughanowr (2013) Process Systems Analysis and Control, 3rd ed., McGraw-Hill.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/103106116
2. https://nptel.ac.in/courses/103103153
3. https://nptel.ac.in/courses/102102033
4. https://nptel.ac.in/courses/103105054
5. https://nptel.ac.in/courses/102106053

Course Outcomes (COs):

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

1. Predict the order and rate of the different reactions. (PO – 1,2; PSO – 1)
2. Analyze the batch bioreactor data for enzyme kinetics. (PO – 2,3; PSO – 3)
3. Design the suitable bioreactor for different biochemical reactions. (PO – 2,3,4; PSO – 3)
4. Predict the Residence time distribution to determine the conversion in non-ideal flow reactors. (PO – 3,4; PSO – 2)
5. Predict the response of first order, second order and first order system in series for various input changes. (PO – 1,2, 9; PSO -1)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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	10	CO2, CO4
Numerical test/ Quiz	10	CO1, CO3, CO5
Semester End Examination (SEE)	100	CO1, CO2, CO3, CO4, CO5

NANOTECHNOLOGY	
Subject Code: BT52	**Credits: 2:1:0**
Prerequisites: None	**Contact Hours: 28L+14P**
Course Coordinator(s): Dr. Roshni Ramachandran and Dr. Samrat K	

Course content

UNIT-I

Introduction to Nanotechnology and Nanobiotechnology

History and scope of nanotechnology; role of size in nanomaterials: Properties of nanomaterials- Physical &Chemical properties. Electronic structure: quantum dots, quantum wires and quantum wells, confinement of electrons energy quantization.

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Links: https://archive.nptel.ac.in/courses/118/107/118107015/

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 Powerpoint presentation
- Links: https://archive.nptel.ac.in/courses/118/107/118107015/

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, 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/

UNIT-IV

Application of Nanotechnology

Nanoparticles in everyday materials and processes, Environmental Remediation, Energy, Biomedicine and Food and Textile Industry

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links:https://www.nano.gov/about-nanotechnology/applications-nanotechnology
  https://archive.nptel.ac.in/courses/118/107/118107015/

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.. 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

LIST OF EXPERIMENTS

1. Implementing Laboratory Safety and Best Practices for Handling Nanomaterials
2. Synthesis of Zinc Oxide and Calcium Aluminate Nanocomposite via Solution Combustion Method
3. Fabrication of Iron Oxide Nanoparticles Using Co-Precipitation Techniques
4. Comparative Analysis of Sol-Gel and Hydrothermal Methods in the Synthesis of Nano Magnesia
5. Microwave-Assisted Preparation of Carbon Quantum Dots (CQDs)
6. Characterization of Nanomaterials Through Powder X-ray Diffraction Analysis
7. Morphological and Particle Size Evaluation of Nanoparticles Using SEM/TEM Methods
8. Analysis of Nanoparticle Surface Area Through BET Techniques

9. Spectroscopic Characterization of Nanoparticles Using UV-Visible and FTIR Methods
10. Assessing the Thermal Stability and Decomposition of Nanoparticles via DSC/TGA Methods
11. Investigating the Antimicrobial Properties of ZnO Nanoparticles
12. Evaluating the Antioxidant Efficacy of ZnO Nanoparticles
13. Adsorptive Removal of Dyes Using Calcium Aluminate Nanocomposites
14. Photocatalytic Degradation of Environmental Pollutants with TiO2 Nanoparticles

Text Books:

1. B.S. Murty, P. Shankar, Baldev Raj, B B Rath, James Murday (2013), Textbook of Nanoscience and Nanotechnology, Springer
2. Risal Singh, Shipra Mital Gupta, (2016), Introduction to nanotechnology, Oxford press

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 instrumentation. 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=LnyUzmQM83U
4. https://www.youtube.com/watch?v=US-8vnKo85E
5. https://pubmed.ncbi.nlm.nih.gov/28393698/
6. https://www.slideshare.net/sumeetsharma32/nanomaterials-in-biomedical-application

Course Outcome (COs):

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

1. Develop an understanding of the fundamental concepts in nanotechnology and different classes of nano-materials. (PO2, 3 and 5)
2. Impart basic knowledge of various synthesis techniques involved in nanoparticle fabrication for a specific function. (PO2, 3,5 and 12)
3. Describe applications of various techniques used in the characterization of nanomaterials, (PO2, 3,5 and 12)
4. Think of novel, future applications of nanotechnology in various fields related to biotechnology (PO3,4,5,6,7 and 12)
5. Have knowledge in Applications of Nano-Drug Delivery, Diagnostics and Nanotherapeutics. (PO3,4,5,7 and 12)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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		
Continuous Assessment in lab	10	CO1, CO2, CO3, CO4 & CO5
Lab Test	10	CO1, CO2, CO3, CO4 & CO5
Semester End Examination (SEE)	100	CO1, CO2, CO3, CO4 & CO5

GENOMICS, PROTEOMICS & BIOINFORMATICS	
Subject Code: BT53	**Credits: 3:0:0**
Prerequisites: Molecular Biology	**Contact Hours: 42L**
Course Coordinator(s): Dr. Bhavya S G	

Course content

UNIT-I

Genome Sequencing & Genome Projects

Genes and proteins, organization and structure of genomes, genome size, sequence complexity, introns and exons, genome sequences and database subscriptions. Genome organization. Genome size and C-value paradox. DNA sequencing methods: Sanger dideoxy method, Maxam Gilbert method, Pyrosequencing, Automated Fluorescence method. Introduction to second-generation sequencing: Next Generation Sequencing technology (NGS), basic concepts, Stages of NGS technology. Introduction to third generation sequencing: Nanopore technologies. Comparison of second-generation sequencing and third-generation sequencing systems. Human Genome Project- Shotgun and Clone contig methods, Organelle genome: Mitochondria. Translational Genomics: applications in medicine and agriculture.

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

UNIT-II

Functional Genomics & Proteomics

cDNA library and EST library. SAGE, Microarrays in functional genomics. Introduction to Structural genomics, Comparative genomics, Metagenomics and Transcriptomics. Introduction to proteomics: The origin and scope of proteomics, The Proteome and the Genome, Deducing the proteome from the genome. Basic principles of proteomics. Evolution from protein chemistry to proteomics. Protein sequencing and techniques: Protein sequencing by Edman technique. Molecular biology techniques mass spectrometry techniques. Strategies for protein separation: Extracting proteins from biological samples. Types of biological samples: tissue, body fluids, cell lines. Sample preparation and prefractionation steps: Protein estimation, Protein separations before digestion, Protein digestion: principles, methodology and enzymes (Trypsin, Pepsin and Chymotrypsin).

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation

UNIT-III

Proteomic Approaches and Metabolomics:

Mass spectrometry-based methods for protein identification. The bottom-up approach and top-down methods. Overview of mass spectrometry-based proteomics workflow. Steps involved in proteomics. Ionization techniques: MALDI and ESI: Concepts, principles and methodology. Mass spectrometry: basic principles and instrumentation. Schematic representation of a mass spectrometer. Mass analyzers, ion trap and LTQ orbitrap. General workflow approaches for Qualitative proteomics and Quantitative (TMT/iTRAQ) proteomics. Posttranslational modification (PTM): introduction, types of posttranslational modification. Enrichment techniques for PTM proteins. Application of proteomics to study Posttranslational modification. Metabolomics: Types of approaches in metabolomics techniques. Mass spectrometry in metabolomics. Metabolomics methodology and workflow. Integrated metabolomics and proteomics approaches for health and disease.

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation

UNIT-IV

Bioinformatics

Database: (Definition of database, Types), Biological Database: Databases (Primary, Secondary and Specialized), Interconnection between the databases. Nucleotide and Protein sequence and structure databases, Format of databases: (GenBank flat file, FASTA Format, PIR Format, PDB format), Other Important Databases: KEGG, PubMed, PubChem and any other newly created databases of importance. Sequence Alignment: Pairwise alignment- Alignment algorithm, Homology versus Similarity, Similarity versus Identity. Dynamic programming method: Global alignment, Local alignment, Gap penalties. Database Similarity Searching: BLAST and FASTA. Scoring Matrices: PAM and BLOSUM. Multiple sequence alignment, Motif, Domain and Gene Prediction in prokaryotes and eukaryotes. Phylogenetics Basics, Terminologies, Tree Construction, Tree building methods, Forms of tree representation.

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation

UNIT-V

Structural Bioinformatics

Protein structure prediction, comparison and Visualization: Secondary and Tertiary structure prediction: ab initio, homology-based, neural networks method. Protein structure comparison: intra-molecular method, intermolecular method. Protein structure building (Homology modelling), Protein structure comparison: SCOP and CATH, Protein Structure Visualization tools. Bioinformatics in pharmacy: drug

discovery process, structure-based and ligand-based drug design (CADD). Pharmacokinetics: absorption, distribution, metabolism, excretion and toxicity of drugs. Principles of molecular docking-Molecular dynamics and simulations.

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation

Text Books:

1. T A Brown (2017), Genomes, 4th edition, Garland Science.
2. Daniel C Liebler (2002), Introduction to proteomics: Tools for the new biology, Humana Press.
3. Jonathan Pevsner (2015), Bioinformatics and Functional Genomics, 3rd edition, John Wiley & Sons, Inc.

Reference Books:

1. Aurther M Lesk (2012), Introduction to Genomics, Oxford University Press.
2. Nawin Mishra (2010), Introduction to Proteomics: Principles and Applications, John Wiley & Sons Publications.
3. Richard M. Twyman (2013) Principles of Proteomics, Garland Science.
4. Arthur Lesk (2016), Introduction to Protein Science: Architecture, Function, and Genomics, 3rd Edition, Oxford University Press.
5. Arthur Lesk (2013), Introduction to Bioinformatics, Fourth Edition, Oxford University Press.

Web links and Video Lectures:

1. DNA Sequencing Methods
   https://www.digimat.in/nptel/courses/video/102104056/L10.html
2. Proteomics
   https://nptel.ac.in/courses/102103017
3. Mass spectrometry-based proteomics
   https://nptel.ac.in/courses/102101050
4. Fundamentals of Bioinformatics
   https://onlinecourses.swayam2.ac.in/cec21_bt04/preview

Course Outcomes (COs):

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

1. Apply DNA/genome sequencing techniques to genome projects. (PO-1, 5, 11; PSO-2)
2. To correlate the relationship between Genome, Transcriptome and Proteome. (PO- 2, 3, 4, 5, 6, 9; PSO-2)
3. Apply various proteomics approaches to biological samples. (PO-2, 3, 4, 5, 10; PSO-3)

4. Compare various bioinformatics tools used for sequence alignment and phylogenetic studies. (PO-2, 4, 5, 9; PSO-3)
5. To predict protein structure and apply bioinformatics for drug discovery (PO-2, 4, 5, 9; PSO-3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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 (SEE)	100	CO1, CO2, CO3, CO4 & CO5

IMMUNOLOGY	
Subject Code: BT54	**Credits: 3:0:0**
Prerequisites: Biochemistry	**Contact Hours: 42L**
Course Coordinator(s): Dr. Dhamodhar P & Dr. Bindu S	

Course content

UNIT-I

Immune System

Introduction, Cells and Organs of the immune system: Hematopoiesis, Cells of the myeloid and lymphoid lineage, Lymphoid cells, Primary and secondary Lymphoid organs, Antigens, Adjuvants, Haptens. Classification of immune system -innate and adaptive immunity. Complement and their biological functions, Cytokines and their role in immune response.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://a.impartus.com/ilc/#/course/590888/1030
  https://archive.nptel.ac.in/courses/102/105/102105083/#

UNIT-II

Humoral and Cell mediated immunity

B-lymphocytes and their activation; Basic structure of Immuno globulins; immunoglobulin classes and biological activity, Antigenic Determinants on Immunoglobulins: Isotype, Allotype & Idiotype. Thymus derived lymphocytes (T cells) and types, MHC Complex, Structure and functions of MHC molecules. Antigen processing and presentation: Endogenous & Exogenous pathway. Antigen presenting cells (APCs), Mechanism of T cell activation.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://a.impartus.com/ilc/#/course/590888/1030
  https://archive.nptel.ac.in/courses/102/105/102105083/#

UNIT-III

Immunological disorders

Hypersensitivity and its types, Autoimmune disorders and types, pathogenic mechanisms. Primary and Secondary immunodeficiency disorders (AIDS). Transplantation Immunology: Types of grafts, Grafts acceptance and rejection, Immunological basis of graft rejection, Clinical manifestations, HLA typing and matching.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://a.impartus.com/ilc/#/course/590888/1030
  https://archive.nptel.ac.in/courses/102/103/102103038/

UNIT-IV

Molecular Immunology

Production of monoclonal antibodies: Hybridoma technology and their applications, Antibody Engineering: Chimeric and Hybrid Monoclonal Antibodieof s, Application stem cells to produce antibodies, Immunotherapy with genetically engineered antibodies. Active and Passive Immunisation, Vaccines and their types: Live attenuated, inactivated, subunit vaccines, recombinant, DNA vaccines.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://a.impartus.com/ilc/#/course/590888/1030

UNIT-V

Immunodiagnosis

Antigen antibody interaction –Precipitation reactions, Agglutination reactions, Blood typing, A, B, ABO and Rh. Principles and applications of ELISA, radio immuno assay (RIA), western blot analysis, immuno-electrophoresis, Immunofluorescence, Flow cytometry.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://a.impartus.com/ilc/#/course/590888/1030
  https://archive.nptel.ac.in/courses/102/103/102103038/

Text Books:

1. Thomas J. Kindt, Richard A. Goldsby and Barbara A. Osborne (2006) Kuby Immunology 6th Edition, W.H. Freeman.
2. Peter J. Delves, Seamus J. Martin, Dennis R. Burton and Ivan M. Roitt (2011) Roitt's Essential Immunology, Wiley-Blackwell.

Reference Books:

1. IanTizard (2006) Immunology – An Introduction, Cengage Learning (RS).
2. Eli Benjamini, Geoffrey Sunshine and Sidney Leskowitz (2000) Immunology: A short course, 3rd Revised edition, Wiley-Blackwell.

Web links and Video Lectures (e-Resources):

1. https://a.impartus.com/ilc/#/course/590888/1030
2. https://archive.nptel.ac.in/courses/102/103/102103038/

Course Outcomes (COs):

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

1. Classify and describe the functions of the major components of the immune system in human. (PO-1; PSO-1)
2. Differentiate the humoral and cell mediated response against infectious antigens. (PO-1; PSO-1)
3. Analyze the basis for Immunological disorders and understand the pathogenesis. (PO-1; PO-2; PSO-1)
4. Analyze the recent advancement in molecular immunology. (PO-3; PO-5; PSO-2, PSO-3)
5. Identify the appropriate Immunological technique for diagnosis of infectious diseases. (PO-1, PO-5; PSO-2, PSO-3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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	10	CO4 & CO5
Quiz	10	CO1, CO2, CO3
Semester End Examination (SEE)	100	CO1, CO2, CO3, CO4, CO5

PLANT AND AGRICULTURAL BIOTECHNOLOGY	
Subject Code: BTE551	**Credits: 3:0:0**
Pre requisites: Molecular Biology	**Contact Hours: 42L**
Course Coordinator(s): Dr. Priyadarshini Dey	

Course content

UNIT-I

Introduction to Plant tissue culture

Introduction and historical developments and applications of Plant tissue and cell culture. Laboratory Design and Developments. Instrumentation. Sterilization techniques, Plant Tissue Culture Media-kinetics of growth and nutrient optimization, Cellular totipotency, Factors affecting Tissue Culture success: (Media explant, light, Temperature, Subculture, Genotype, Season), Hormones.

- Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
- Links for History of plant cell and tissue culture: https://www.youtube.com/watch?v=8LiiKFWltyo&list=PLyqSpQzTE6M9DE2RR4pIHDaf_7A4m3RWY&index=3

UNIT-II

Plant Tissue and cell culture techniques

Organogenesis organ culture, Establishing callus and cell culture, Micropropagation for large scale production of plantlets: - banana, Acclimatization of micro propagated plant. Somaclonal variation, Somatic embryogenesis in plant. Synthetic seeds and their commercial potential. Protoplast isolation and culture. Cell suspension culture for production of secondary metabolites. Hairy root culture, Plant products of industrial importance.

- Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
- Links for Somaclonal variation and Micropropagation: https://www.youtube.com/watch?v=7YkXxr0mL_0&list=PLyqSpQzTE6M9DE2RR4pIHDaf_7A4m3RWY&index=10

UNIT-III

Genetic Engineering in Plants

Transfer of DNA to plant cells- Direct transformation by electroporation and particle gun bombardment. Agrobacterium, Ti plasmid vector Theory and techniques for the development of new genetic traits, Plastid transformation. Transgenic plants and their importance, Transgenic crop plants: herbicide tolerances, insect resistance. Selection

of clones and maintenance of germplasm. Genetic fidelity testing. Marker assisted selection. Methods for crop improvement.

- Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
- Links for Genetic transformations in plant cells: https://www.youtube.com/watch?v=XEwFfVHVRmg&list=PLyqSpQzTE6M9DE2RR4pIHDaf_7A4m3RWY&index=23

UNIT-IV

Introduction to Agricultural Biotechnology

Introduction, history and scope of agriculture in India. Agro-climatic zones and cropping pattern of India. Conventional crop improvement programs- Introduction, Selection and Hybridization, Mutation, Haploidy and Polyploidy Breeding. Soil less cultivation or hydroponics. Modern agriculture biotechnology for food security and national economy. Green-revolution. Industries that are based on agricultural raw materials. Impact of biotech-products on the national economy and trade. Improvements of raw material for the food processing industry.

- Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
- Links for Polyploidy: https://www.youtube.com/watch?v=j9-Z9ywDlrU

UNIT-V

Organic agriculture and genetic conservation

Modernization of agricultural practices and national food security. Sustainable food production: organic farming for improvement of food quality and soil fertility. Composting, Biofertilizers. Integrated pest management. Various renewable biofuels: Bioethanol, Biodiesel, Biogas an alternative fuel, Importance and strategies of Biodiversity Conservation. Impact of Biotechnology on Biological diversity and genetic conservation.

- Pedagogy/Course delivery tools: Chalk and talk and Powerpoint presentation
- Links for Mechanism of trans-esterification and biodiesel production: https://www.youtube.com/watch?v=kS1OEZrXdvs

Text Books:

1. Singh, B.D. (2022) Plant Biotechnology. 4th Edition, MedTech Science Press.
2. Singh, K.H., Thakur, A.K., & Parmar, N. (2019) Agricultural Biotechnology at a Glance. 1st Edition, Science technology.
3. Jain, V.K. (2022) Fundamentals of Plant Physiology. 20th Edition, S. Chand

Reference Books:

1. Razdan, M.K. (2019) An Introduction to Plant Tissue Culture.3rd Edition, Oxford & IBH.

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=cZLMq8ccSGs&list=PLJoALJA_KMOBh42ul_4yk4nx_K5hTrmBe
2. https://www.youtube.com/watch?v=DJz8wqQb3dw&list=PLJoALJA_KMOBh42ul_4yk4nx_K5hTrmBe&index=2

Course Outcomes (COs):

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

1. Understand the basic concept of plant tissue culture, media formulation, and its importance. (PO-2, 3, 4; PSO-2)
2. Understand the concept of different techniques involved in plant tissue culture. (PO-3, 4; PSO-2)
3. To analyze the developments of crop production by using plant breeding and hybridization techniques. (PO-3, 4, 7; PSO-2)
4. To apply knowledge of molecular markers for the identification of traits in various genomes. (PO-3, 4, 7; PSO-2)
5. Apply modern agricultural techniques and understand the importance of bioresources (PO-5, 7; PSO-2).

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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	10	CO1, CO2
Quiz	10	CO3, CO4, CO5
Semester End Examination (SEE)	100	CO1, CO2, CO3, CO4, CO5

FUNCTIONAL FOODS & NUTRACEUTICALS	
Subject Code: BTE552	**Credits: 3:0:0**
Pre requisites: None	**Contact Hours: 42L**
Course Coordinator(s): Dr. G Divyashri	

UNIT-I

Introduction

Definition of the functional food, nutraceuticals, dietary supplements and natural health products. Historical perspective and evolution. List of functional foods and nutraceuticals with their benefits. Criteria that discriminate between conventional and functional foods. Foods, health promotion and disease prevention. Market scenario, Formulation considerations & its Challenges.

- Course delivery tools: Chalk and talk and Power point presentation
- Links for topic: https://www.youtube.com/watch?v=gCeSLR5PFIc https://www.youtube.com/watch?v=G98hKVxEa24

UNIT-II

Probiotics, Prebiotics and Synbiotics

Pro, pre and synbiotics-definition and history. Classification, physiology and characterization. Use of pro and prebiotics in the formulation of functional foods with examples. Antimicrobials, Nutraceuticals and high value metabolites produced by probiotics. Safety considerations. FAO/WHO Guidelines. Efficacy of probiotics in Human Subjects. Probiotics in Animal Production and Health.

- Course delivery tools: Power point presentation
- Links: https://www.youtube.com/watch?v=lrSsCGeOAuc

Unit-III

Nutraceuticals

Nutraceuticals of plant origin: Plant secondary metabolites- Terpenoids, Phenolics, Alkaloids, phytoestrogens, Pigments, Organosulphur compounds. Sources and health benefits of nutraceuticals with key examples (Glucans, ascorbic acid, quercitin, β-carotene, allicin). Nutraceuticals of animal origin (chitin, chondroitin sulphate, conjugated linoleic acid, eicosapentenoic acid, docosahexenoic acid, lecithin): source and validated health benefits with pre-clinical and clinical evidences. Nutraceutical analysis, characterization and quantification.

- Course delivery tools: Power point presentation
- Links: https://www.youtube.com/watch?v=ghiZZbDrjcw
- https://www.youtube.com/watch?v=jN9Ghf2WjRc

Unit-IV

Functional Foods and Nutraceuticals as Remedies

Functional food development: Formulation and fortification. Functional foods and nutraceuticals bridging the gap between food and drug. Functional Foods and Chronic Diseases (heart disease, CVD and/or hypertension). Functional Foods and the Gut (IBD), Functional Foods and Weight Management (Obesity), Functional Foods and Aging (Antioxidant ability), Functional Foods and Immune Health (Infectious diseases), Functional Foods and Mental Health (Neuroprotection and/or Cognitive impairment), Functional Foods and Special Populations (Children, adolescents and geriatrics).

- Course delivery tools: Power point presentation
- Links: https://www.youtube.com/watch?v=QxORI49hcI4
  https://www.youtube.com/watch?v=0ni9kMBTCjg

Unit-V

Safety Issues

Health Claims, Adverse effects and toxicity of functional foods and nutraceuticals, regulations and safety issues- International and national.

- Course delivery tools: Power point presentation
- Links: https://www.youtube.com/watch?v=h3jXl190EXQ
  https://www.youtube.com/watch?v=2j8s4xeg8pM

Text Books:

1. Brian Lockwood (2007). Neutraceuticals. Pharmaceutical Press, USA
2. Wildman, Robert (2007). Nutraceuticals and Functional Foods, second edition. Taylor and Francis Group.
3. Saarela M (2011) Functional Foods: Concept to Product. 2nd edition. Oxford, Cambridge. Woodhead Publishing Ltd Bagchi D.
4. Gibson GR & William CM (2000). Functional Foods - Concept to Product.

Reference Books:

1. Handbook of Nutraceuticals and Functional Foods, Second Edition, Eds Robert E.C. Wildman, CRC Press, Taylor and Francis.
2. Phenolics in Food and Nutraceuticals, Fereidoon Shahidi, Marian Naczk, CRC press.
3. Bioactive Proteins and Peptides as Functional Foods and Nutraceuticals, Eds Yoshinori Mine, Eunice Li-Chan, Bo Jiang, Wiley Blackwell.

Course Outcomes (COs):

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

1. Course outcome 1: Describe components of nutraceutical and functional foods. (PO-1,2,4 PSO-1,2)
2. Course outcome 2: Able to gain knowledge on regulator status and laws (PO-1,2,3,4 PSO-2,3)
3. Course outcome 3: Learn about role of Probiotics, Prebiotics and Symbiotics as health benefits and their product development (PO-1,3,4 PSO-2,3)
4. Course outcome 4: Able to gain knowledge on components in functional foods (PO-1,3,4 PSO-2,3)
5. Course outcome 5: Evaluate functional foods for their anti-nutritional factors. (PO-1,3,4 PSO-2,3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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	10	CO1, CO2, CO3, CO4, CO5
Quiz	10	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE)	50	CO1, CO2, CO3, CO4, CO5

PHARMACEUTICAL BIOTECHNOLOGY	
Subject Code: BTE553	**Credits: 3:0:0**
Pre requisites: None	**Contact Hours: 42L**
Course Coordinator(s): Dr. K N Lokesh	

Course content

UNIT-I

Introduction to Pharmaceutical Biotechnology

Scope, past, present and future prospects, drug development process (drug discovery, formulation and development, preclinical and clinical trial and regulatory approval process). Concepts of formulation and development and different types of pharmaceutical dosage forms.

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Link: https://elearn.nptel.ac.in/shop/iit-workshops/completed/data-science-applications-in-genomics-and-drug-discovery/

UNIT-II

Pharmacokinetics and Pharmacodynamics

Introduction to pharmacokinetics and pharmacodynamics, Drug metabolism- half-life of drugs, physico chemical principles, Biotransformation/pharmacokinetic studies, elimination and distribution of protein therapeutics, pharmacodynamics principles.

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Link: https://www.youtube.com/watch?v=G2i-YKL6IHU

UNIT-III

Recent Advances in Pharmaceutical Biotechnology

Introduction to nutraceuticals, edible vaccines, commercially available important diagnostic kits, diagnostic kits for detection of blood sugar, HIV, Malaria etc, recent advances in diagnostic kits, Nanomedicines and nanoformulation.

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Link: https://onlinecourses.nptel.ac.in/noc22_bt40/preview

UNIT-IV

Manufacturing Principles

Manufacturing facilities, clean room design, Industrial scale Cleaning decontamination and sanitation operations, CIP protocol, analytical quality control studies. Proto-type manufacturing operations of recombinant biotherapeutics such as insulin, erythropoietin and blood clotting factors.

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Link: https://www.gmp-compliance.org/training/gmp-course-conference/gmp-compliance-for-biopharmaceuticals

UNIT-V

Formulations of Biopharmaceuticals

Excipients used in parental formulations, methods to enhance shelf life of protein formulations, delivery of protein (rate controlled, target specific, site specific, soluble carrier system etc) different packaging techniques & quality control.

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Link: https://onlinecourses.nptel.ac.in/noc19_bt23/preview

Text Books:

1. Heinrich Klefenz (1995) Industrial Pharmaceutical Biotechnology, Wiley-VCH.
2. Gary Walsh (2013) Biopharmaceuticals: Biochemistry and Biotechnology, 2nd Edition, John Wiley & Sons, Inc.
3. Crommelin, D. J., & Sindelar, R. D. (2008). *Pharmaceutical biotechnology: fundamentals and applications*. CRC Press.

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, John Wiley & Sons, Inc.
2. Susanna Wu-Pong, Yongyut Rojanasakul, and Joseph Robinson 2006) Biopharmaceutical Drug Design and Development, Humana Press.
3. Herbert A Kirst, Wu-Kuang Yeh, Milton J (2001) Enzyme technologies for p harmaceutical and biotechnological applications, Marcel Dekker, Inc.

Web links and Video Lectures:

- https://www.youtube.com/watch?v=zLISlgi0KUg&list=PLQnNyE1lxfVJeyPkYzYziZnOOu8MY1owA
- https://www.gmp-compliance.org/training/gmp-course-conference/gmp-compliance-for-biopharmaceuticals

Course Outcomes (COs):

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

1. Correlate the importance of Pharmacy with other basic science for development of novel therapeutics and diagnostics. (PO-3, 5, 6, 12; PSO-1,2,3).
2. Assess pharmacokinetic and Pharmacodynamic profile of new drug candidates. (PO-1, 2, 3, 12; PSO-1,3).
3. Comprehend the principles of immunodiagnostics or other recent technologies for development of therapeutics or diagnostics (PO-1,3, 12; PSO-1,2,3).
4. Apply GMP / GLP guidelines in development or processing of Biopharmaceuticals. (PO-1,2, 3, 5, 6,12; PSO-3).
5. To understand the importance formulation of biopharmaceuticals to improve therapeutic efficiency. (PO-1, 2, 3,5,6,12; PSO-1, 2,3).

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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/Test	10	CO1, CO2, CO3, CO4 & CO5
Semester-End Examination (SEE)	100	CO1, CO2, CO3, CO4 & CO5

BIOMEDICAL ENGINEERING	
Subject Code: BTE554	**Credits: 3:0:0**
Pre requisites: Biochemistry	**Contact Hours: 42L**
Course Coordinator(s): Dr. Prabha M & Dr. Lokesh K N	

Course content

UNIT I

Fundamentals of Biomedical Engineering:

Fundamental technologies of biomedical engineering, Biomechanical Modeling; Biomechanical Testing Techniques; Fundamental of Bio Molecular Engineering: molecular cloning, genomic libraries, PCR, DNA sequencing, genomics etc., Fundamental concepts of immunology of biomedical relevance, Introduction to Automated Biotechnology: new work planners, expert systems, data-handling software and automation hardware (e.g., robots).

- Pedagogy/Course delivery tools: Chalk and talk and Power Point Presentation
- Link: https://nptel.ac.in/courses/102101068
  https://www.youtube.com/watch?v=4Qeqrr5rtb0

UNIT-II

Polymeric composites of Biomedical Applications:

Fundamental approach on polymer and polymeric composites of Biomedical applications, Synthesis of biobased polymer composites, Biomedical applications of electrospun polymer composites, Biomedical application of hydroxyapatite nanocomposites, Engineering tissues for replacing bone, cartilage, tendons, ligaments, skin and liver, Bioreactors for Tissue Engineering.

- Pedagogy/Course delivery tools: Chalk and Talk, Power Point Presentation
- Links: https://nptel.ac.in/courses/102106057
  https://nptel.ac.in/courses/102106081
  https://nptel.ac.in/courses/102108077

UNIT-III

Biomedical Instrumentation and System Measurements:

Analytical & Diagnostic Equipment, Therapeutic equipment, Sphygmomanometer, automation of chemical tests. Cardiovascular System Measurements: Electrocardiograph, ECG machines, vector cardiography (VCG), Respiratory System Measurements: Measurement of gas volume, respiratory transducers, Measurement of

Electrical Activity in Neuromuscular System and Brain: Neuron potential, muscle potential

- Pedagogy/Course delivery tools: Chalk and Talk, Power Point Presentation
- Links: https://nptel.ac.in/courses/117108148
  https://www.youtube.com/watch?v=_YfAG_I3aPI
  https://www.robots.ox.ac.uk/~gari/teaching/b18/lecture_slides/B18_LectureA.pdf

UNIT-IV

Biological sensors & Medical Imaging:

Sensors / receptors in the human body, basic organization of nervous system-neural mechanism, Chemoreceptor: hot and cold receptors, barro receptors, sensors for smell, sound, vision, Ion exchange membrane electrodes, enzyme electrode, glucose sensors, immunosensors, Basic principles of MOSFET biosensors & BIOMEMS, basic idea about Smart sensors. Computer assisted medical imaging- nuclear medicine, Image analysis tools, Identifying Medical Diagnoses and treatable diseases by image based deep learning. Ultrasound imaging ultrasonography-computed X-ray tomography, Radiation therapy.

- Pedagogy/Course delivery tools: Chalk and Talk, Power Point Presentation
- Links: https://www.youtube.com/watch?v=iK-6q4nnmtA
  https://nptel.ac.in/courses/117108148
  https://www.youtube.com/watch?v=oAW48H4ntik
  https://nptel.ac.in/courses/102105090
  https://archive.nptel.ac.in/courses/102/105/102105090/

UNIT-V

Recent Advances and Applications in Biomedical Engineering:

Quantum dots Treatment, Nanochip for HIV detection (targeting Cd4)., Liposomal mediated drug delivery, Nanotechnology based chemotherapy Nanorobotics, Cancer (pebble brain cancer) Nanoparticles A platforms for cancer therapy, Tissue culture 3D printing, Textiles and wound care products, Active implantable devices and bionics, Dendrimer,. Artificial tissue engineering implementation and applications.

- Pedagogy/Course delivery tools: Chalk and Talk, Power Point Presentation
- https://nptel.ac.in/courses/102108077
  https://nptel.ac.in/courses/102107058
  https://nptel.ac.in/courses/102106095

Text Books:

1. Mark Saltzman (May 21, 2015) Fundamental Biomedical Technologies Cambridge University Press; 2nd edition
2. Joseph D. Bronzino, Donald R. Peterson. (February 26, 2018) Biomedical Engineering Fundamentals (The Biomedical Engineering Handbook, Fourth Edition) 2nd Edition CRC Press; 2nd edition.
3. Furukawa (2014) Biological Imaging and Sensing, Springer-Verlag Berlin Heidelberg.

References:

1. Professor Mark Walters (25 February 2015) Biomedical Engineering Applications, Clanrye International; Illustrated edition
2. Pfeiffer Erich A. (2014) Biomedical Instrumentation and Measurements Prentice-Hall of India Pvt.Ltd Second Edition
3. Sadasivuni, K.K., Ponnamma, D., Rajan, M., Ahmed, B., Al-Maadeed, M.A.S.A. (Eds.) (2019) Polymer Nanocomposites in Biomedical Engineering 1 st Edition
4. Pascal Verdonck (2008) Advances in Biomedical Engineering Elsevier Science, 1 st Edition

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/102101068 (NPTEL- bioengineering an interface with biology and medicine)
2. https://nptel.ac.in/courses/102106057 (NPTEL- Biomaterials)

Course Outcomes (COs):

1. Apply the core concepts of Biomedical Engineering, its underlying Fundamentals of Bimolecular Engineering and Automated Biotechnology. (PO-1,2,3,6 &11, PSO-1)
2. Utilize the fundamental approach on polymer and polymeric composites of Biomedical applications for Engineering tissues for replacing bone, skin and other organs. (PO-1,2,3,6 & 11, PSO-3)
3. Analyze and measure the Analytical & Diagnostic Equipment and Therapeutic Equipment's to understand the various organs functions of the human. (PO-1, 2, 3, 6, 11 & 12, PSO- 2)
4. Demonstrate the biomolecules and sensory cell function with biological sensors, Advanced imaging instruments and Computer assisted medical imaging. (PO-1, 2, 3, 5, 6, 11, & 12, PSO-3)
5. Apply Recent Advances and Applications in Biomedical Engineering to produce solutions for diagnosis and treatment of human diseases. (PO-1,2,3,5,6,11 &12, PSO-3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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. And 20 for other components		
Other Components		
Assignment & case studies	10	CO1, CO2, CO3
Mini Project write up	10	CO4, CO5
Semester End Examination (SEE)	100	CO1, CO2, CO3, CO4, CO5

BIOINFORMATICS LAB	
Subject Code: BTL56	**Credits: 0:0:1**
Pre requisites: None	**Contact Hours: 14P**
Course Coordinator(s): Dr. Bhavya S G	

LIST OF EXPERIMENTS

1. Biological data retrieval from the bibliography database and working with referencing format
2. Pairwise sequence comparison of the sequences retrieved from nucleic acid/protein database
3. Sequence similarity search using BLAST tool and analysis of parameters affecting alignment
4. Multiple Sequence Alignment (MSA) and comparison of different MSA tools
5. Molecular Phylogenetics analysis
6. Gene prediction for prokaryotic and eukaryotic genome
7. Retrieval of protein structure, visualization and analysis
8. Prediction of secondary structures for protein sequences
9. Prediction of tertiary structure for protein sequence using homology modelling and structure validation
10. Construction of restriction map for given DNA sequence and analysis of restriction sites
11. Design of PCR primers and analysis of parameters affecting the primer
12. Bioinformatics analysis of proteomics data- Gene ontology, protein-protein interactions and pathway analysis
13. Retrieval and analysis of biological big datasets from the NGS database
14. Prediction of ADME properties of ligands and performing molecular docking studies

Note: Any 12 experiments must be performed

Reference Books:

1. Jonathan Pevsner, Bioinformatics and Functional Genomics, 3rd Edition, John Wiley & Sons, Inc, 2015.
2. Arthur Lesk., Introduction to Bioinformatics, 4th Edition, Oxford University Press, 2013.
3. Michael Agostino, Practical Bioinformatics, 1st Edition, Garland Science publisher, 2012.

Web links and Video Lectures:

1. Retrieving articles using PubMed
   https://vlab.amrita.edu/?sub=3&brch=273&sim=1442&cnt=1
2. Aligning Multiple Sequences with CLUSTAL W
   https://vlab.amrita.edu/?sub=3&brch=274&sim=1438&cnt=1
3. Pairwise Sequence Alignment using BLAST
   https://vlab.amrita.edu/?sub=3&brch=274&sim=1428&cnt=1
4. Fundamentals of Bioinformatics
   https://onlinecourses.swayam2.ac.in/cec21_bt04/preview

Course Outcomes (COs):

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

1. Perform sequence alignment to identify the regions of similarity in DNA/RNA/protein sequences using appropriate sequence alignment methods (PO-2, 4, 5, PSO-2)
2. Construct and analyse the phylogenetic tree to understand the evolutionary relationships of organisms using appropriate phylogeny tools (PO-2, 4, 5, PSO-2)
3. Predict the functional sites in DNA sequence using online gene prediction tools (PO-4, 5, PSO-2)
4. Predict the secondary and tertiary structure of proteins and visualise using available open-source tools (PO-4, 5, PSO-2)
5. Apply the computational tools to address important problems of biotechnology (PO-4, 5, PSO-2)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Weekly evaluation of laboratory manuals/ reports after the conduction of every experiment.	30	CO1, CO2, CO3, CO4, CO5
Practical test	20	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE)	50	CO1, CO2, CO3, CO4, CO5

IMMUNOTECHNOLOGY LAB	
Subject Code: BTL57	**Credits: 0:0:1**
Pre requisites: Biochemistry Lab	**Contact Hours: 14P**
Course Coordinator(s): Dr. Dhamodhar P and Dr. Abhijith S.R	

LIST OF EXPERIMENTS

1. ABO Blood grouping & Rh typing
2. Radial Immunodiffusion
3. Ouchterlony Double Immunodiffusion (ODD)
4. Immunoelectrophoresis (IEP)
5. Counter Immunoelectrophoresis (CIEP)
6. Rocket Immunoelectrophoresis
7. Widal & VDRL tests
8. Total Blood count (RBC & WBC).
9. Differential count of WBC
10. Dot ELISA
11. Indirect Enzyme-linked Immunosorbent assay (ELISA)
12. Latex Agglutination
13. Flow cytometry demonstration (Instrumentation) and applications
14. Western blotting demonstration

Any 12 experiments must be performed.

Reference Books:

1. Barbara Detrick (2016) Manual of Molecular and Clinical Laboratory Immunology, 8th Edition. Wiley
2. Rastogi SC (1996) Immundiagnostics. New Age International
3. Frank C Hay (2002) Practical Immunology. Blackwell Science.

Web links and Video Lectures (e-Resources):

1. https://ivl1-au.vlabs.ac.in/
2. https://ivl2-au.vlabs.ac.in/

Course Outcomes (COs):

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

1. Design and analyze the key concepts in immunological reactions, and to interpret the data. (PO-1, 2, 3, 4; PSO-1)

2. Select the appropriate Immunological technique for diagnosis of infectious diseases. (PO-1, 2; PSO-2)
3. Analyze and interpret various components of blood sample.PO-1, 2, 4; PSO-2)
4. Apply the knowledge of Immunological techniques in implementing research projects. (PO-1, 2, 3; PSO-2)
5. Distinguish various types of blood groups in humans. (PO-1, 2, 3; PSO-2)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Weekly evaluation of laboratory manuals/ reports after the conduction of every experiment.	30	CO1, CO2, CO3, CO4, CO5
Practical test	20	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE)	50	CO1, CO2, CO3, CO4, CO5

RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS	
Subject Code: AL58	**Credits: 3:0:0**
Pre requisites: Nil	**Contact Hours: 42L**
Course Coordinator(s): Course Faculty	

Course content

UNIT-I

Introduction to Research Methodology: Meaning of Research, Objectives of Research, Types of Research, Ethics in Research, Types of Research Misconduct. Literature Review and Technical Reading, New and Existing Knowledge, Analysis and Synthesis of Prior Art, Bibliographic Databases, Conceptualizing Research, Critical and Creative Reading.

Citations: Functions and Attributes, Impact of Title and Keywords on Citations, Knowledge flow through Citations, Acknowledgments, and Attributions.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://onlinecourses.nptel.ac.in/noc22_ge08/preview

UNIT II

Research Design: Need for Research Design, Important Concepts Related to Research Design: Dependent and Independent Variables, Extraneous Variable, Variable, Common Control, Confounded Relationship, Research Hypothesis, Experimental and Control Groups, Treatments.

Experimental Designs: Introduction to Randomised Block Design, Complete Randomised Design, Latin Square Design, and Factorial Design.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://onlinecourses.nptel.ac.in/noc22_ge08/preview

UNIT-III

Method of Data Collection: Primary and Secondary Data Collection.

Sampling Design: Sampling fundamentals, Measurement, and Scaling Techniques, Criteria of Selecting a Sampling Procedure, Characteristics of a Good Sample Design, and Types of Sample Design.

Data Analysis: Testing of Hypotheses: Null Hypothesis, Alternative Hypothesis, Type I and Type II Errors, Level of Significance. Procedure for Hypothesis Testing: Mean, Variance, Proportions. Chi-square Test, Analysis of Variance (One Way ANOVA), and Covariance (ANOCOVA)

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://onlinecourses.nptel.ac.in/noc23_ge36/preview

UNIT-IV

Introduction to Intellectual Property Rights

: Different forms of IPR, Role of IPR in Research and Development. TRIPS Agreement, Patent Cooperation Treaty (PCT).

Patents: Brief history of Patents-Indian and Global Scenario, Principles Underlying Patent Law, Types of Patent Applications in India, Procedure for Obtaining a Patent. Non Patentable Inventions. Rights Conferred to a Patentee, Basmati Rice Patent Case.

- Pedagogy: Chalk and Talk, PowerPoint Presentations
- Links: https://archive.nptel.ac.in/courses/110/105/110105139/

UNIT-V

Design: What is a Design? Essential Requirements for a Registrable Design, Procedure of Registration of a Design,

Trademarks: Essentials of a Trademark, Registration, and Protection of Trademarks, Rights Conferred by Registration of Trademarks, Infringements, Types of Reliefs, Case Studies.

Copyrights: Characteristics of Copyrights, Rights Conferred by Registration of Copyrights, Registration of Copyrights, Infringements, Remedies against Infringement of Copyrights, Case studies

Pedagogy: Chalk and Talk, PowerPoint Presentations

Links: https://archive.nptel.ac.in/courses/110/105/110105139/

Text Books:

1. C. R Kothari, Gourav Garg, Research Methodology – Methods and Techniques. New Age International Publishers.
2. Dr. B L Wadehra – Law relating to Intellectual property. Universal Law Publishing Co.
3. Dipankar Deb, Rajeeb Dey, Valentina E. Balas "Engineering Research Methodology", ISSN 1868-4394 ISSN 1868-4408 (electronic), Intelligent Systems Reference Library, ISBN 978-981-13-2946-3 ISBN 978-981-13-2947-0 (eBook), https://doi.org/10.1007/978-981-13-2947-0.

Reference Books:

1. David V. Thiel "Research Methods for Engineers" Cambridge University Press, 978-1-107-03488-4

Course Outcomes (COs):

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

1. Possess the knowledge of research and conduct a literature review. (PO-8, PO-10, PO-12)

2. Apply the knowledge of research design and design of experiments. (PO-4, PO-8, PO 10, PO-12)
3. Analyse data collection methods, analysis, and sampling design. (PO-4, PO-8, PO-10, PO-12)
4. Understand the global and Indian scenarios of patents and patent applications. (PO-8, PO-10, PO-12)
5. Acquire the requirements of registration and infringements related to trademarks, copyrights, and designs. (PO-8, PO-10, PO-12)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	**Marks**	**Course outcome attained**
Internal test - 1	30	CO1, CO2, CO3
Internal test - 2	30	CO4, CO5
The average of the two internal tests will be taken for 30 marks		
Other Components		
Assignment	10	CO1, CO2
Quiz	10	CO3, CO4, CO5
Semester End Examination (SEE)	100	CO1, CO2, CO3, CO4, CO5

ABILITY ENHANCEMENT COURSE - V	
Subject Code: AEC510	**Credits: 1:0:0**
Pre requisites: Nil	**Contact Hours: 14L**
Course Coordinator(s): Any Department	

Ability Enhancement Courses (AEC) are the generic skill courses which are basic and needed by all to pursue any career. These courses are designed to help students enhance their skills in communication, language, and personality development. They also promote a deeper understanding of subjects like social sciences and ethics, culture and human behaviour, human rights and the law.

Every student shall register for AEC course under the supervision of his/her proctor. For III, IV & V semester, the student shall select the Ability Enhancement Course online such that the selected course does not overlap with any professional core/ elective course offered by the parent department of the student. After selection, the registration of the course has to be done by the student at his/her parent department.

ENVIRONMENTAL STUDIES	
Subject Code: HS59	**Credits: 0:0:0**
Pre requisites: Nil	**Contact Hours: 14L**
Course Coordinator(s): Dr. H U Raghavendra & Jyothi M R	

Course content

UNIT-I

Environment, Ecology and Biodiversity

Definition, scope and importance. Multidisciplinary nature of Environmental studies. Food chain and food web. Energy flow and material cycling in ecosystem. Biodiversity and threats to biodiversity. Concept of sustainable development: Definition, objectives and applications.

- Pedagogy/Course delivery tools: Chalk and Talk, Power point presentations, Videos, Models
- Links: https://archive.nptel.ac.in/courses/110/105/110105139/
  https://youtu.be/I_bnGkviWOU
  https://youtu.be/Ar04qG1P8Es

UNIT-II

Natural Resources

Forest resources: Ecological importance of forests. Water resources: Global water resources distribution. Mineral resources: Environmental effects of extracting and processing Mineral resources. Food resources: Effects of modern agriculture. Land resources: Soil erosion and Desertification.

- Pedagogy/Course delivery tools: Chalk and Talk, Power point presentations, Videos, Models
- Links: https://youtu.be/vsXv3anIBSU
  https://youtu.be/1rOVPqaUyv8

UNIT-III

Energy sources

Growing energy needs. Conventional and non-conventional / Renewable and Non-renewable energy sources. Bio energy-Ethanol and Bio mass energy. Energy of the future – Hydrogen fuel cells and Nuclear enegry. Environmental Impact Assessment (EIA): Definition, Objectives and benefits. Step-by-step procedure of conducting EIA.

- Pedagogy/Course delivery tools: Chalk and Talk, Power point presentations, Animations, Models
- Link: https://youtu.be/mh51mAUexK4
  https://youtu.be/XS-eXqppf_w

Unit IV

Environmental pollution

Definition, Causes, Effects and control measures of Water pollution, Air pollution and Soil/ land pollution. Management of Municipal solid Waste and treatment methods of municipal solid waste.

- Pedagogy/Course delivery tools: Chalk and Talk, Power point presentations, Videos
- Link: https://youtu.be/NRoFvz8Ugeo
  https://youtu.be/DAQapF-F4Vw

Unit V

Environmental protection

Global warming and Climate change, Acid rain, Ozone layer depletion. Salient features of Environmental Protection Act, Air & Water Acts. Functions of Central and State Pollution Control Boards.

- Pedagogy/Course delivery tools: Chalk and Talk, Power point presentations, Opens source softwares
- Link: https://youtu.be/iV-BvYwl4Y8
  https://youtu.be/BYqLRGawoH0

Text Books:

1. Dr. S M Prakash – Environmental Studies, Elite Publishers, 2007.

Reference Books:

2. **P. Venugopala Rao** – Principles of Environmental Science & Engineering Prentice Hall of India, 1st edition, 2006.

Web links and video Lectures (e- Resources):

1. https://youtu.be/I_bnGkviWOU
2. https://youtu.be/vsXv3anIBSU
3. https://youtu.be/mh51mAUexK4
4. https://youtu.be/NRoFvz8Ugeo
5. https://youtu.be/iV-BvYwl4Y8

Course Outcomes (COs):

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

1. Describe the importance of environmental studies, sustainable development and biodiversity (PO-1, 7)
2. Explain the importance and conservation of impacts of natural resources (PO-1, 7)

3. Distinguish the energy sources and identify the alternative energy sources for sustainable development (PO-1, 7)
4. Identify the causes, effects and control measures of pollution in developmental activities (PO-1, 7)
5. Outline the current environmental issues and the role of the agencies for environmental protection (PO-1, 7)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	CO1, CO2, CO3
Internal Test-II	30	CO4, CO5
Average of the two internal test shall be taken for 30 marks		
Other components		
Assignment – MCQ, Objectives	10	CO1, CO2
Assignment – Quiz, Group presentation	10	CO3, CO4
Semester End Examination (SEE)	50	CO1, CO2, CO3, CO4, CO5

VI Semester

MANAGEMENT & ENTREPRENEURSHIP	
Subject Code: AL61	**Credits: 3:0:0**
Pre requisites: Nil	**Contact Hours: 42L**
Course Coordinator(s): Dr. M Rajesh/Dr. Siddhartha Kar	

Course content

UNIT-I

Introduction to Management: Definition of Management, Its nature and purpose, Contributions of F.W. Taylor and Henry Fayol to management theory, Functions of managers.

Planning: Types of plans, Steps in planning, the planning process, Management By Objectives (MBO)

Organizing: The nature and purpose of organizing, Formal and informal organization. Organization levels and Span of management, Principle of span of management, the structure and process of organizing

- Pedagogy: Chalk and Talk, Power point presentations
- Link: https://onlinecourses.nptel.ac.in/noc23_mg33/preview
  https://www.digimat.in/nptel/courses/video/110107150/L01.html

UNIT –II

Staffing: Situational factors affecting staffing.

Leading: Human factors in managing, definition of leadership, Ingredients of leadership

Controlling: Basic control process, Critical control points and standards, Control as a feedback system, Feed forward control, Requirements for effective controls.

- Pedagogy: Chalk and Talk, Power point presentations
- Link: https://nptel.ac.in/courses/110107150

UNIT-III

Introduction to Entrepreneurship

Foundations of Entrepreneurship: What is an Entrepreneurship? The benefits of Entrepreneurship, The potential drawbacks of Entrepreneurship; Inside the Entrepreneurial Mind: From Ideas to Reality: Creativity, Innovation and Entrepreneurship, Creative Thinking, Barriers to Creativity

- Pedagogy: Chalk and Talk, Power point presentations
- Link:https://www.youtube.com/watch?v=Hgj_kRrvbhQ&list=PL7oBzLzHZ1wXW3mtolxV5nIGn48NLKwrb

UNIT-IV

Entrepreneurial Journey

Crafting a Business Plan: The benefits of creating a business plan, The elements of a business plan; Forms of Business Ownership and Buying an Existing Business: Sole proprietorships and partnership.

- Pedagogy: Chalk and Talk, Power point presentations
- Link:https://www.youtube.com/watch?v=Tzzfd6168jk&list=PLyqSpQzTE6M8EGZbmNUuUM7Vh2GkdbB1R

UNIT-V

Launching the Business

Franchising and the Entrepreneur: Types of Franchising, The benefits of buying a Franchise; E-Commerce and the Entrepreneur: Factors to consider before launching into E-commerce, Ten Myths of E-Commerce.

- Pedagogy: Chalk and Talk, Power point presentations
- Link:https://www.youtube.com/watch?v=5RMqxtMwejM&list=PLyqSpQzTE6M9zMKj_PSm81k9U8NjaVJkR

Text Books:

1. Harold Koontz, H. Weihrich, and A.R. Aryasri, Principles of Management, Tata McGraw-Hill, New Delhi, 2004.
2. Essentials of Entrepreneurship and Small Business Management – Norman Scarborough & Jeffrey Cornwall (Pearson, 2016)

References

1. Innovation & Entrepreneurship – Peter Drucker (Harper, 2006)
2. Entrepreneurship: The Art, Science, and Process for Success – Charles Bamford & Garry Bruton (McGraw-Hill, 2015)
3. Managent and Enterpreneuship-NVR Naidu, T Krishna Rao, I.K. International Publishing House Pvt. Ltd.@ 2008
4. Poornima M Charantimath, Entrepreneurship Development and Small Business Enterprises, Pearson Education, 2006.

Course Outcomes (COs):

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

1. Plan and organize for the manpower in the given type of organization (PO: 6,9,11)
2. Use staffing Leading and controlling function for the given organization. (PO: 6,8,9,10)
3. Understand the fundamentals of entrepreneurship with the goal of fulfilling the requirements of the industries and holding the responsibilities towards the society. (PO-6,7,8)
4. Design a basic business plan by considering case studies and show the involvement of ownership in Business. (PO-3,7,8,11)
5. Start a new small business with the help of E-Commerce and the current available technologies. (PO-5,11)

UPSTREAM & DOWNSTREAM BIOPROCESSING	
Subject Code: BT62	**Credits: 2:1:0**
Pre requisites: None	**Contact Hours: 28L+14T**
Course Coordinator(s): Dr. KN Lokesh & G Divyashri	

Course content

UNIT-I

Introduction to Upstream Bioprocessing

Introduction to upstream bioprocessing (reactive bioprocessing): Upstream processing of microbial and plant cells. Overview of fermentation process. Microbial and plant media constituents, formulation and optimization. Somatic embryogenesis & Artificial seed production. Bioprocess consideration in using plant cell cultures: Bioreactors for suspension cultures, immobilized cells reactor technology. Production of industrially important primary and secondary metabolites.

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Link: https://onlinecourses.nptel.ac.in/noc21_bt23/preview

UNIT-II

Animal Cell Technology

Animal cell technology: Characteristics of animal cells. Media for culturing animal cells and tissues; development of animal cell lines, maintenance and cryopreservation of animal cell lines and viability assessment. Specialized animal cell culture techniques: Fibroblast cultures, lymphocyte culture, stem cell isolation and culture. Bioreactors considerations for animal cell cultures and reactors. Production of Monoclonal antibodies.

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Link: https://archive.nptel.ac.in/courses/102/104/102104059/

UNIT-III

Basics of Downstream Processing and Separation Techniques

Basics of downstream processing and Separation techniques: Role & Importance of downstream processing in biotechnological processes. Characteristics of biological mixtures, process design criteria for various classes of bioproducts (high volume, low value products and low volume, high value products). Cell disruption methods for intracellular products, removal of insolubles, biomass (and particulate debris) separation techniques; flocculation and sedimentation, centrifugation and filtration methods.

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

- Links: https://www.digimat.in/nptel/courses/video/102106022/L01.html
  https://onlinecourses.nptel.ac.in/noc20_bt25/preview
  https://nptel.ac.in/courses/103105060

UNIT-IV

Product Enrichment Operations and Membrane Separation

Product Enrichment operations and Membrane Separation: Precipitation methods with salts, organic solvents, and polymers. Aqueous two-phase extraction, supercritical extraction. Solute polarization and cake formation in membrane ultra-filtration – causes, consequences and control techniques.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://archive.nptel.ac.in/courses/102/106/102106048/
  https://onlinecourses.nptel.ac.in/noc22_ch14/preview
  https://www.youtube.com/watch?v=ArANJh5DPzs

UNIT-V

Final Product Formulation and Finishing Operations

Final product formulation and finishing operations: Hybrid Separation Techniques (Membrane chromatography, Electrochromatography, etc). Crystallization – Principles, Nucleation, CrystalGrowth – Kinetics, crystallization of proteins. Drying and lyophilization in final product formulation. Quality Assurance and Regulatory affairs in Downstream Processing.

- *Pedagogy/*Course delivery tools: Chalk and talk and Power point presentation
- Links: https://www.youtube.com/watch?v=5ArAs0srDcw
  https://www.youtube.com/watch?v=wQcBtS2KsmQ
  https://www.youtube.com/watch?v=3qEwfIif89U

Text Books:

1. Scopes R.K (1993) Protein Purification, IRL Press.
2. Upadhyay, Upadhyay, and Nath (2003) Biophysical Chemistry Principles and techniques, Himalaya Publishing House.
3. Sivasankar B (2005) Bioseparations: Principles and Techniques, Eastern Economy Edition.

Reference Books:

1. Wankat PC (1990) Rate controlled separations Elsevier
2. Belter PA and Cussier E (1985) Bioseparations, Wiley
3. Product Recovery in Bioprocess Technology - BIOTOL Series, VCH, 1990
4. Asenjo J and Dekker M (1993) Separation processes in Biotechnology

5. Okotore RO (2002) Basic Separation Techniques in Biochemistry, New age publishing Co.
6. Robert K. Scopes (ed.) (2004) Protein purification principles and practice, Springer International
7. Simon Roe (2006) Protein purification Techniques (2nd Edn) Oxford University Press.

Course Outcome (Cos):

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

1. Apply appropriate strategy for scale up of microbes, plants and animals to obtain product of interest (PO 1,2,5,7,8,9).
2. Identification and implementation of animal cell culture techniques for scale up. (PO 1,2,3,4,6,7,10).
3. Identify appropriate unit operations based on nature of biomolecules or complex bioprocess parameters (PO 1,3,5,6,7,8,10).
4. Apply appropriate unit operation for isolation, purification and characterization of bioproduct (PO-1,3,5,6,7,8,10).
5. Evaluate different unit operations for product crystallization and Drying (PO 1,2,5,8).

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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	10	CO1, CO2, CO3, CO4, CO5
Quiz	10	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE)	50	CO1, CO2, CO3, CO4, CO5

DRUG DESIGN AND DEVELOPMENT	
Subject Code: BTE631	**Credits: 3:0:0**
Pre requisites: -	**Contact Hours: 42L**
Course Coordinator(s): Dr. K N Lokesh	

Course content

UNIT-I

Drug discovery & development

Introduction to Drug design and development pathway. Classification of drugs, Drug nomenclature. Types of Drug targets, Miscellaneous drug targets: Lipids, carbohydrates, biosynthetic building blocks. Safety and efficiency assessment by preclinical and clinical studies using Pharmacokinetics & Pharmacodynamics parameters, introduction to pharmaceutical regulatory affairs.

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Link: https://elearn.nptel.ac.in/shop/iit-workshops/completed/data-science-applications-in-genomics-and-drug-discovery/

UNIT-II

Enzymes as drug targets

Enzyme kinetics, Inhibitors acting at the active site of an enzyme-Inhibitors acting at allosteric binding sites, Uncompetitive and non-competitive inhibitors- Transition-state analogues, Suicide substrates, Medicinal uses of enzyme inhibitors

Receptors as drug targets: Role of the receptor, Neurotransmitters and hormones, Receptor types and subtypes, Receptor activation. Receptors and signal transduction, Design of agonists and antagonists, Partial agonists, Inverse agonists, Desensitization and sensitization, Tolerance and dependence, Affinity, efficacy, potency.

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Link: https://archive.nptel.ac.in/courses/102/106/102106070/

UNIT-III

Nucleic acids as drug targets: Intercalating drugs acting on DNA, Topoisomerase poisons: non-intercalating, Alkylating and metallating agents, Chain cutters. Chain terminators, Control of gene transcription, Agents that act on RNA components. Antisense therapy.

Target identification: Choosing a disease, Choosing a drug target, Target specificity and selectivity, Multi-target drugs, Identifying a bioassay, Finding a lead compound,

Properties of lead compounds, Isolation and purification, Structure determination & characterization

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Link: https://archive.nptel.ac.in/courses/102/106/102106070/

UNIT-IV

Drug Design

Structure activity relationships, Identification of a pharmacophore, Drug optimization, Optimizing access to the target: Optimizing hydrophilic/hydrophobic properties-Making drugs more resistant to chemical and enzymatic degradation, Making drugs less resistant to drug metabolism, Prodrugs, Drug alliances, Endogenous compounds as drugs, Peptides and peptidomimetics in drug design

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Link: https://elearn.nptel.ac.in/shop/iit-workshops/completed/data-science-applications-in-genomics-and-drug-discovery/

UNIT-V

***In silico* Drug Design**

Computer aided lead design-Determining Target Structure: Literature, Experimental methods, Protein structure Prediction methods, Molecular Modelling-Complementarity between a Target and Drug: Intermolecular Forces, molecular shape, drug pharmacophore, Ligand Based drug design, Structure Based drug design, Fragment Based Drug Design, Computer aided drug design, Molecular Docking procedures: software for molecular docking**,** steps in molecular docking. Quantitative structure–activity relationship (QSAR).

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Link: https://onlinecourses.nptel.ac.in/noc21_bt29/preview

Text Books:

1. Erland Stevens. Medicinal Chemistry: The Modern Drug Discovery Process, Prentice Hall; 2nd edition, 2012.
2. Graham L. Patrick. An Introduction to Medicinal Chemistry, 5th Edition, Oxford University Press, USA. 2013.

Reference Books:

1. Gareth Thomas. Medicinal Chemistry: An Introduction, Wiley-Blackwell, 2nd Edition, 2007.
2. Rick Ng, Drugs: From Discovery to Approval, Wiley-Blackwell; 3rd Edition, 2015.

Web links and Video Lectures:

- https://onlinecourses.nptel.ac.in/noc21_bt29/preview
- https://www.youtube.com/watch?v=3Gl0gAcW8rw
- https://onlinecourses.nptel.ac.in/noc21_bt29/preview

Course Outcomes (COs):

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

1. Correlate the relationship between various steps of Drug design & development
2. process. (PO-2, 3; PSO2)
3. Classify and compare various molecular drug targets. (PO-2, 3, 4; PSO2)
4. Identify the target and develop lead molecules. (PO-2, 4, 6; PSO-3)
5. Optimization of lead and development of drug candidate. (PO-2, 3, 5; PSO-3)
6. Evaluate the role of Bioinformatics in *in-silico* drug design. (PO-2, 4, 5, 6; PSO-3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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 Test	10	CO1, CO2, CO3, CO4 & CO5
Semester-End Examination (SEE)	100	CO1, CO2, CO3, CO4 & CO5

ENZYME ENGINEERING & TECHNOLOGY	
Subject Code: BTE632	**Credits: 3:0:0**
Pre requisites: Biochemistry	**Contact Hours: 42L**
Course Coordinator(s): Dr. P. Dhamodhar & Dr. Ahalya N	

Course content

UNIT-I

Introduction to Enzymes

Introduction to enzymes, Classification, enzyme sources, extraction from sources. Strategies for purification of enzymes, criteria of purity, specific activity, fold purification and % yield in purification, molecular weight determination. Mechanism of enzyme action: Acid base catalysis, Covalent catalysis, Metal ion catalysis with examples.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://a.impartus.com/ilc/#/course/59747/295
  https://onlinecourses.swayam2.ac.in/cec20_bt20/preview

UNIT-II

Enzyme Engineering & its applications

Enzymes in Organic Solvents, Advantages of biocatalysts in organic media, Enzyme-catalyzed peptide synthesis: enzymatic conversion of porcine into human insulin, Artificial Enzymes, Surface-Modified & Chemically Modified Enzymes, Design and construction of novel enzymes, Enzyme Engineering cycle, Protein engineering of enzymes: Site directed mutagenesis, Rational design, De novo enzyme design, Designer enzymes, Engineering substrate specificity.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://a.impartus.com/ilc/#/course/59747/295

UNIT-III

Enzyme immobilization & its applications

Different techniques of immobilization of enzymes and whole cells: Adsorption, Ionic binding, Covalent Attachment, Cross-Linking, Matrix entrapment, Entrapment into Membrane Compartments, Economic argument for immobilization. Applications of immobilized enzyme technology: Industrial Production of HFCS, Production of L – Amino acids, semi synthetic Penicillin, aspartame, Enzyme Electrodes, Enzyme based biosensors and their applications.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://a.impartus.com/ilc/#/course/59747/295
  https://onlinecourses.swayam2.ac.in/cec20_bt20/preview

UNIT-IV

Medical applications of Enzymes

Enzymes of Biological Importance: Acetylcholine esterase and pseudo cholinesterase, Angiotensin converting enzyme (ACE) and Inhibitors, HMG CoA reductase inhibitors, Importance of enzymes in diagnosis, Enzyme pattern in diseases like Myocardial infarctions (CK, AST, & LDH), Liver disease. Isoenzymes (CK, LDH isoforms). Use of isoenzymes as markers in diagnosis. Enzymes in immunoassay techniques, Therapeutic enzymes.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://a.impartus.com/ilc/#/course/59747/295

UNIT-V

Industrial applications of Enzymes

Enzymes in cheese production, Enzymes in Starch Processing, Enzymes in Sucrose Industry, Use of Lactase in dairy industry, Glucose Oxidase & Catalase in Food Industry, Proteases in Meat tenderization, Enzymes in Baking Industry. Enzymes used in detergents, Enzymes in leather industries, Enzymes for textile, paper and pulp industries.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://a.impartus.com/ilc/#/course/59747/295
  https://onlinecourses.swayam2.ac.in/cec20_bt20/preview

Text Books:

1. Nicholas C. Price and Lewis Stevens (2006), Fundamentals of Enzymology: Cell and Molecular Biology of Catalytic Proteins, 3rd Edition, Oxford University Press.
2. Kurt Faber (2011), Biotransformations in Organic Chemistry: A Textbook, 6th Edition. Springer.

Reference Books:

1. Young Je Yoo, Yan Feng, Yong-Hwan Kim, Camila Flor J. Yagonia (2017) Fundamentals of Enzyme Engineering, 1st Edition, Springer.
2. Gerhatz W (1990) Enzymes in Industry Production and Applications, VCH publishers.
3. Dordrick JS (1991) Biocatalysts for Industry. Plenum Press.
4. Chaplin MF and Bucke C (1990) Enzyme technology. Cambridge University Press.
5. Trevor Palmer and Philip Bonner (2008) Enzymes: Biochemistry, Biotechnology and clinical Chemistry. 2nd Edition, East West Press Pvt. Ltd.

Web links and Video Lectures (e-Resources):

1. https://a.impartus.com/ilc/#/course/59747/295
2. https://onlinecourses.swayam2.ac.in/cec20_bt20/preview

Course Outcomes (COs):

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

1. Classify the enzymes, understand the mechanism of enzyme action and select the appropriate analytical techniques for purification and characterisation of enzymes. (PO-1; PO-2; PO5; PSO-1)
2. Acquaint with the tools and techniques for enzyme engineering for industrial needs. (PO-1; PO-3; PO-5; PSO-3)
3. Apply different techniques of immobilization and analyze the applications of immobilization of industrially important enzymes. (PO-1; PO-3; PO5; PSO-1; PSO-3)
4. Identify the role and use of various enzymes in diagnosis and treatment of diseases. (PO-1; PO-3; PSO-2, PSO-3)
5. Identify the current and possible future industrial applications of enzymes. (PO-1; PO-3; PSO-2, PSO-3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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	CO4 & CO5
Quiz	10	CO1, CO2, CO3
Semester End Examination (SEE)	**100**	CO1, CO2, CO3, CO4, CO5

ANIMAL BIOTECHNOLOGY	
Subject Code: BTE633	**Credits: 3:0:0**
Pre requisites: None	**Contact Hours: 42L**
Course Coordinator(s): Dr. Roshni Ramachandran	

Course content

UNIT-I

Introduction to animal biotechnology

Introduction, History and Scope; Cell culture Laboratory design & Equipment: Layout of animal facility (both immunocompromised as well as control group); Maintenance of sterility; Cryopreservation; Media and reagents, CO2 and bicarbonates buffering, Different Types culture Media-Natural and Artificial Media. Principles of cell and tissue culture. Different tissue culture techniques; primary culture; Secondary culture;

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links:https://video.ucdavis.edu/media/Animal+biotechnology+1+Lecture/0_8xmpwywh/151672082
  https://onlinecourses.swayam2.ac.in/cec22_bt07/preview

UNIT-II

Animal cell culture

Initiation of Cell Culture-Preparation and Sterilization of substrate, Isolation of Explants, Disaggregation of explants, contamination. Process of Adherence of cells onto substrate, Cell culture techniques of adherent and non-adherent culture. Passage or subcultivation of adherent and suspension culture. Trypsinization; Continuous cell lines; Suspension culture; Organ culture etc.; Behavior of cells in culture conditions: Morphology, division, growth pattern; Development of cell lines Characterization and maintenance of cell lines.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://archive.nptel.ac.in/courses/102/104/102104059/
  https://www.vanderbilt.edu/viibre/CellCultureBasicsEU.pdf

UNIT-III

Animal cell culture applications

Cell cloning and selection; Commercial scale production of animal cells, stem cells and their application; Application of animal cell culture for in vitro testing of drugs, Application of cell culture technology in production of human and animal viral vaccines, Hybridoma Culture monoclonal antibody production and its applications. Culture products- interferon's, hybrid antibodies

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7325846/
  https://www.youtube.com/watch?v=u-kueNZPrlU
  https://www.youtube.com/watch?v=O55R09egthg

UNIT-IV

Development and use of transgenic animals

Transfection and its methods and applications. Transgenic animals; Transgenic-mice methodology: Mammalian virus vector- Retroviral vector method, SV40 vector DNA microinjection method, Engineered-embryonic stem cell method, Transgenic animals produced- Mice, Rabbits, Goat, Sheep and fish. Transgene integration. Targeted gene transfer- Gene disruption and Gene replacement. Knocking in and knocking out of genes; Applications: transgenic animals as bioreactors for production of proteins of pharmaceutical value; Cell culture products- interferon's, hybrid antibodies

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://www.youtube.com/watch?v=SEUmKt_xijE
  https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10169938/

UNIT-V

Biotechnology for animal improvement

Conventional methods of animal improvement: cross breeding, artificial insemination, in vitro fertilization, embryo transfer technology; Ethical issues related to IVF. Cryopreservation- procedure and applications. Gene mapping, marker assisted selection and genetic improvement of desired characters of domestic animals. Detection of Transgene and transgene function. Rapid diagnosis of diseases in live-stock via: RIA, ELISA and PCR

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://www.youtube.com/watch?v=X3GymDPJbi8
  https://www.sciencedirect.com/science/article/abs/pii/B9780128222652000156

Text Books:

1. Freshney RI (2016) Culture of Animal Cells, 7th Edn, Wiley-Blackwell Publisher.
2. Spier RE and Griffiths JB (2012) Animal Cell Biotechnology, Academic Press.
3. Clynes (1998) Animal Cell Culture Techniques, 1st Edn, Springer.

Reference Books

1. Channarayappa (2006) Molecular Biotechnology**:** Principles and Practices. University Press (India) Pvt. Ltd., Worldwide CRC Press.

2. Channarayappa (2010) Cell Biology: Universities Press (India) Pvt Ltd.
3. John RW, Masters, (2000) Animal Cell Culture: Practical Approach, 3rdEdn, Oxford.
4. Murray Moo-Young (1989) Animal Biotechnology, Pergamon Press, Oxford.
5. Doyle A, Hay R, and Kirsop BE (1990) Living Resources for Biotechnology, Animal cells, Cambridge University Press

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=IB2scTv3anw
2. https://www.youtube.com/watch?v=qCIvAuwaf-o
3. https://www.youtube.com/watch?v=G1n3BgmcVMA
4. https://kosheeka.com/9-applications-of-animal-cell-culture
5. https://edurev.in/v/78216/Transgenic-Animals-Biotechnology-and-its-Applicati
6. https://www.youtube.com/watch?v=Y5fsCZUzExQ

Course Outcomes (COs):

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

1. Apply the basics and principles of animal biotechnology. (PO – 2,3,4,5; PSO - 1)
2. Analyze the basic cellular and molecular biology techniques and their applications in a real-world research setting. (PO2,3,5,8; PSO - 2)
3. Application of stem cells, cloning, large animal models for disease and development of therapies and treatments. (PO – 2,3,5, 9, 10; PSO - 2,3)
4. Scientific idea in the development of recent methods available for animal cell culture and its applications (PO – 2,5,9,10; PSO – 3).

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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/Assignment	10	CO1, CO2, CO3, CO4, CO5
Assignment/Paper presentation	10	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE)	100	CO1, CO2, CO3, CO4, CO5

BIOPROCESS ENGINEERING	
Subject Code: BTE634	**Credits: 3:0:0**
Pre requisites: Fundamentals of Biochemical Engineering	**Contact Hours: 42L**
Course Coordinator(s): Dr. Krishna Murthy T P & Dr. Chandraprabha M N	

Course content

UNIT-I

Introduction to Bioprocess Engineering

The origins and domains of (bio)process engineering, the early history of (bio)process engineering, the Industrial era of (bio)process engineering, green and clean technologies, sustainable bioprocessing, types of bioprocesses and bioproducts. Presentation and analysis of bioprocess data, conservation laws, steady and unsteady state mass and energy balances. Analogies between transport of momentum, heat and mass, Solution of transport equations.

- Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint Presentation
- Links:https://youtu.be/xVhrfm1vJMY?list=PLbV6qbj31bqVTdYfXCB3IaJYgUyLjK-py

UNIT-II

Hydrodynamics in Bioprocess Systems

Rheological properties of fermentation broths, factors affecting broth Viscosity-Functions of mixing, mixing equipment, flow patterns in a stirred tank, impellers, stirrer power requirements, power input by gassing, impeller pumping capacity, suspension of solids, mechanism of mixing, assessing mixing effectiveness, scale-up of mixing systems, improve mixing in bioreactors, multiple impellers, retrofitting effect of rheological properties on mixing, the role of shear in stirred bioreactors.

- Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint Presentation
- Links: The Impact of Mixing on Cell Culture in Bioreactors
  https://www.youtube.com/watch?v=mS_5x7cju7E
  The Impact of Sparging on Cell Culture in Bioreactors
  https://www.youtube.com/watch?v=7Pnrnjt6pyo

UNIT-III

Gas-Liquid Mass Transfer in Bioprocessing

Role of diffusion in bioprocessing, film theory, convective mass transfer, oxygen uptake in cell cultures-factors affecting oxygen transfer in bioreactors, measuring dissolved oxygen concentration, estimating oxygen solubility, mass transfer correlations for oxygen transfer, measurement of k_La, measurement of specific oxygen

uptake rate, practical aspects of oxygen transfer in large bioreactors, alternative methods for oxygenation without sparging, oxygen transfer in shake flasks.

- Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint Presentation
- Links: Understanding the Role of Dissolved O2 & CO2 on Cell Culture in Bioreactors https://www.youtube.com/watch?v=j-Lz35T_CJM
  The Impact of Aeration on Cell Culture in Bioreactors
  https://www.youtube.com/watch?v=_T_SdZVI6rI
  https://www.youtube.com/watch?v=Tvku2IXVLjo

UNIT-IV

Mass Transfer in Heterogeneous Bioprocess Systems:

Heterogeneous reactions in bioprocessing, concentration gradients and reaction rates in solid catalysts, mass transfer considerations in heterogeneous systems.

Heat Transfer Applications in Bioprocess Engineering:

Heat transfer equipment, mechanism of heat transfer, heat transfer between fluids, design equations for heat transfer systems, applications of design equations, and hydrodynamic considerations with cooling coils. Sterilisation of media, the kinetics of thermal death of Microorganisms-Batch and Continuous Sterilisers-Heat transfer in the agitated tank and Columns-Heat transfer to dense suspension.

- Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint Presentation
- Links: Enzyme Immobilization Technologies and Industrial Applications
  https://pubs.acs.org/doi/10.1021/acsomega.2c07560

UNIT-V

Cell Culture Bioprocessing & Biomanufacturing:

A brief review of the biopharmaceutical industry, Cell culture, cell culture products, cellular properties critical to biologics production, nutritional requirements, cell line development, bioreactors, Overview of continuous biomanufacturing, Facility Design and Process Utilities, Quality, validation, and regulatory aspects in biomanufacturing. Scale up and scale down of bioprocess systems.

- Pedagogy/Course delivery tools: Chalk and Talk, PowerPoint Presentation
- Links: Continuous integrated manufacturing for biopharmaceuticals: A new paradigm or an empty promise?
  https://onlinelibrary.wiley.com/doi/abs/10.1002/bit.28235

Text Books:

1. Pauline M Doran (2013) Bioprocess Engineering Principles, 2nd Edition, Academic Press.

2. Wei-Shou Hu (2017) Engineering Principles in Biotechnology, John Wiley & Sons, Inc.
3. Ganapathy Subramanian (2017) Continuous Biomanufacturing: Innovative Technologies and Methods, 1st Edition, John Wiley & Sons, Inc.

Reference Books:

1. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). Principles of fermentation technology. 3rd Edition, Elsevier.
2. Koltuniewicz, A. B. (2014). Sustainable Process Engineering: prospects and Opportunities. Walter de Gruyter GmbH & Co KG.
3. El-Mansi, E. M. T., Bryce, C. F., Allman, A. R., & Demain, A. L. (2018). Fermentation Microbiology and Biotechnology. 4th Edition, CRC press.
4. Gunter Jagschies Eva Lindskog Karol Lacki Parrish Galliher (2017) Biopharmaceutical Processing: Development, Design, and Implementation of Manufacturing Processes, 1st Edition, Elsevier B.V.
5. Michael L Shuler, Fikret Kargi (2017) Bioprocess Engineering: Basic Concepts, 3rd Edition, Pearson publishers.
6. Johannes Khinast, Jukka Rantanen. Continuous Manufacturing of Pharmaceuticals, John Wiley & Sons, Inc., 2017

Web links and Video Lectures (e-Resources):

1. Bioreactors https://nptel.ac.in/courses/102106053
2. Bioreactor Design and Analysis https://nptel.ac.in/courses/102106086
3. Plant Cell Bioprocessing https://nptel.ac.in/courses/102106080
4. Aspects Of Biochemical Engineering https://nptel.ac.in/courses/102105064
5. Biochemical Engineering https://nptel.ac.in/courses/103105054

Course Outcomes (COs):

On completion of this course, students will have an improved ability to

1. Analyze the integration of bioprocess engineering in modern chemical technology, particularly focusing on its contribution to sustainable production. (PO-2, 3; PSO-2)
2. Utilize principles of momentum transfer to formulate solutions for complex problems encountered in industrial bioprocessing. (PO-2, 3, 4; PSO-2)
3. Evaluate and implement mass transfer principles in various bioprocessing applications. (PO-2, 4, 6; PSO-3)
4. Assess the implications and importance of heat transfer mechanisms in the efficiency and safety of industrial bioprocesses. (PO-2, 4, 6; PSO-3)
5. Apply bioprocess engineering concepts and methodologies to optimize the manufacturing processes of biopharmaceutical products. (PO-2, 4, 6; PSO-3)

Course Assessment and Evaluation:

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

MEDICAL BIOTECHNOLOGY	
Subject Code: BTE641	**Credits: 3:0:0**
Pre requisites: Immunology, Cell and Molecular Biology	**Contact Hours: 42L**
Course Coordinator(s): Dr. Abhijith S.R and Dr. Lokesh KN	

Course content

UNIT-I

Infectious diseases & Vaccine Technology

Introduction to Medial Biotechnology, scope and applications. Classification of Microbial Diseases of Humans: Viruses (Hepatitis, Rabies, COVID-19) Bacteria (Typhoid, STD, TB), Fungal and parasitic diseases. History and classification of vaccines, strategies for vaccine development, principles of vaccine preparation and standardization, cancer vaccine, AIDS vaccine development, MMR vaccine, Hepatitis vaccine, polio vaccine, COVID-19 vaccine, Future development and scope of vaccines.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://nptel.ac.in/courses/102105083
  https://nptel.ac.in/courses/102103015

UNIT-II

Stem cells & Differentiation

Definition and history, Properties of stem cells, embryonic and adult stem cells, isolation and culturing of embryonic stem cells and their properties, formation of differentiated cells from embryonic stem cells and their properties. Tissue stem cells and their identification, Hematopoietic and mesenchymal stem cells, stem cells of the epidermis, differentiating epidermal cells, models for stem cells differentiation, Neural stem cells.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://in.coursera.org/learn/stem-cells
  https://nptel.ac.in/courses/102106036

UNIT-III

Stem Cell Disorders & Cell therapy

Classification and manifestations of hematopoietic stem cell disorders (Inherited and acquired), concepts of cancer stem cells. Clinical applications of hematopoietic stem cells: bone marrow stem cell transplantation, complications and benefits, stem cell replacement therapy in diseases, immunological principles, Induced pluripotent stem

cells and their application in clinics. Preservation and clinical use of blood and blood components.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://online.stanford.edu/courses/xgen204-stem-cell-therapeutics
  https://dosily.com/course/introduction-to-stem-cell-technology/

UNIT-IV

Molecular Diagnostics

PCR based diagnosis, Southern blot-based diagnosis, DNA sequencing of representative clones to detect mutation(s), PCR-SSCP to detect SNPs, DNA fingerprinting. Protein based diagnostics: protein biomarkers, Applications of Western blotting, immunohistochemistry, ELISA in clinics. Chromosomal based diagnostics: FISH, karyotyping for chromosomal abnormalities, prenatal diagnosis. Application of Next generation sequencing in clinical practice.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://healthsciencesprograms.gwu.edu/programs/post-baccalaureate-certificate-in-molecular-diagnostic-science-online/courses/

UNIT-V

Gene Therapy

General introduction, strategies and approaches, gene transfer methods and their applications, mechanisms of retro and adeno virus mediated gene transfer, ex vivo and in vivo gene therapy. Clinical studies, overview of inherited and acquired diseases for gene therapy; germline gene therapy- advantages and complications. Cancer gene therapy

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://nptel.ac.in/courses/102103041

Text Books:

1. Glick, B. R., Patten, C. L., & Delovitch, T. L. (Eds.). (2020). Medical biotechnology. John Wiley & Sons.
2. Pratibha Nallari and V. V. Rao (2010) Medical Biotechnology. First edition, Oxford University Press.
3. Judit Pongracz, Mary Keen (2009) Medical Biotechnology, A Churchill Livingstone publication.

Reference Books:

1. Ben Hu, Hua Guo et al., (2021) Characteristics of SARS-CoV-2 and COVID-19, Nature Reviews Microbiology, 19, 141-154

2. Mary Clarke, Jonathan Frampton (2020) Stem cells-Biology and application, 1st edition, Taylor and Francis Publisher
3. Albert Sasson, (2006) Medical Biotechnology, Brookings Institution Press.
4. Keith Wilson & John Walker, (2000) Practical Biochemistry- 5th Edition, Cambridge University Press, UK.
5. Daan Crommelin, Robert D Sindelar (2013) Pharmaceutical Biotechnology an Introduction for pharmacists and pharmaceutical scientists, Springer Publisher

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/102103041
2. https://nptel.ac.in/courses/102105083
3. https://nptel.ac.in/courses/102106036

Course Outcome (COs):

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

1. To detect the disease-causing microbes for diagnosis, production of vaccines in prevention and treatment of diseases. (PO–2,5, 11; PSO-1,2)
2. To understand the basic biology of stem cells and their properties (PO–2, 5, 6; PSO-2)
3. To understand the benefits and scope of Embryonic stem cells and adult stem cells for therapeutics and transplantation. (PO–2, 3, 5, 12; PSO-2,3)
4. To apply the molecular and advanced techniques for analysis and diagnosis. (PO–3, 5, 6; PSO-1,3)
5. To analyze the gene transfer methods for application of gene therapy in treatment. (PO–4, 5,12; PSO-1,2)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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		
Assignment and Presentation	10	CO1, CO2, CO3
Quiz	10	CO4, CO5
Semester End Examination (SEE)	100	CO1, CO2,CO3, CO4,CO5

FOOD BIOTECHNOLOGY	
Subject Code: BTE642	**Credits: 3:0:0**
Pre requisites: None	**Contact Hours: 42L**
Course Coordinator(s): Dr. Bindu S	

Course content

UNIT-I

Microorganisms in Foods

History of microorganisms in food, Important milestones in food preservation, Historical perspective and recent trends in food biotechnology. The significance and scope of microorganisms in food w.r.t Spoilage of food, Food borne diseases and Manufacture of food products. Probiotics and their applications. Intrinsic & extrinsic factors of spoilage, Primary sources of microorganisms found in foods, Types of microorganisms in foods. Synopsis of common food-borne bacteria, Synopsis of genera of molds common to foods, Synopsis of genera of yeasts common to foods.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links for **Food borne germs and illnesses**: https://www.cdc.gov/foodsafety/foodborne-germs.html#:~:text=Salmonella%20can%20cause%20salmonellosis%20and, virus%2C%20Shigella%2C%20and%20Yersinia.

UNIT-II

Determining Microorganisms and Their Products in Foods

Culture, microscopic and sampling methods - Conventional methods: Standard Plate Count (SPC), Most Probable Numbers (MPN), Dye-reduction Test (DRT), Direct microscopic count (DMC). Other methods: Membrane filters – Direct Epifluorescent Filter Technique (DEFT), Microcolony DEFT, Hydrophobic Grid Membrane Filter (HGMF) Technique, Agar droplets, Dry films, Roll tubes, Microbiological examination of surfaces/Surface testing, Air sampling: Impaction, Impingement and Sedimentation. Detection and enumeration of food-borne organisms.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links for **Rapid methods for detection of food borne bacteria**: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4290631/#:~:text=One%20of%20the%20most%20commonly,polymerase%20chain%20reaction%20(PCR).

UNIT-III

Food Spoilage and Preservation

Microbial spoilage of vegetables, fruits, fresh and processed meats, poultry, Food preservation using irradiation, Legal Status of Food Irradiation, Effect of Irradiation on food constituents; Food preservation with low temperatures: Chilling, Refrigeration and Freezing, Slow & quick freezing, Effect of freezing on microorganisms. Food preservation with high temperatures: Blanching, Pasteurisation, Sterilisation, Aseptic Packaging, Canning, Factors affecting heat resistance in microorganisms, Effect of drying on microorganisms, Thermal destruction of microorganisms in food -D, Z & F values. Preservation of foods by drying/dehydration, Factors of relevance in control of drying, Changes brought about in food by drying, Storage stability of dried foods, Freeze drying. Evaporation and Evaporative concentration of food products, Factors influencing evaporation.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links for **Different methods of food preservation** and **Food Irradiation**:
  https://foodsafetyhelpline.com/what-are-the-different-methods-of-food-preservation/
  https://apps.who.int/iris/bitstream/handle/10665/38544/9241542403_eng.pdf

UNIT-IV

Biotechnology in Food Industry

Common additives, Organic foods, Prevention of spoilage, Storage and preservation through biotechnological means, Food packaging: Packaging methods and materials: Controlled atmosphere packaging and Modified atmosphere packaging, Vacuum packaging. 3D food printing. Application of supercritical and subcritical extraction in food industry, Membrane based purification and concentration of foods: Nanofiltration, Microfiltration, Ultrafiltration and Diafiltration. Reverse Osmosis. Factors influencing food product development. Introduction to: Nutrition value, Basal metabolic rate, Ecologically sustainable production, Risks and benefits of biotechnology to food industry.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links for **Membrane applications in the food industry:**
  https://link.springer.com/article/10.1007/s12393-020-09262-9

UNIT-V

Nutraceuticals and Phytoceuticals

Water soluble and fat-soluble vitamins, Functions and nutritional importance of vitamins. Deficiency diseases, Prevention. Estimation of vitamins from the sample, Assay of vitamins: Fat soluble & water soluble Essential amino acid, Fatty acids, Bulk and Trace Minerals, Functions and nutritional importance of minerals, Deficiency

diseases, Prevention., Anti-obesity nutraceuticals, and their mode of action, Golden rice – Technology and applications.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links for **Nutraceuticals**: https://www.fssai.gov.in/upload/uploadfiles/files/Compendium_Nutra_29_09_2021.pdf

Text Books:

1. James M Jay, Martin J Loessner and David A Golden (2006) Modern Food Microbiology. 7th Edition, Springer, US.
2. Norman N. Potter and Joseph H. Hotchkiss (2007) Food Science, 5th edition, CBS publishers and distributors.
3. Sivasankar B (2002) Food Processing and Preservation, Paperback Edition, Prentice Hall India.

Reference Books:

1. Nisha Jain, Vijay Singh and Surabhi Sharma (2011) Instant Notes in Food Biotechnology, Paperback Edition, CBS publishers.
2. Gustavo F Gutierrez-Lopez (2003), Food Science and Food Biotechnology, 1st Edition, CRC Press.
3. Anthony Pometto and Kalidas Shetty (2005), Food Biotechnology, 2nd Edition, CRC Press.

Web links and Video Lectures (e-Resources): (Impartus 2022 and 2020)

1. https://a.impartus.com/ilc/#/course/1307165/1205
2. https://a.impartus.com/ilc/#/course/267332/703

Course Outcomes (COs):

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

1. List, identify & distinguish the commonly found microorganisms in food, correlate them to their role & routes of entry into food. (PO-1,2; PSO-2)
2. Differentiate types of spoilages seen in various food categories & suggest methods of preservation. (PO-1,2, 3, 4, 5; PSO-2)
3. Identify & describe the processing & preservation methods practiced in the food industry (PO-1,2,3,4,5; PSO-2)
4. Understand biotechnological methods of food preservation & sustainable food production. (PO-1, 2, 3, 4, 5; PSO-2)
5. Identify & classify minor food components, nutraceuticals & relate them to their roles. (PO-1,2, 4, 5; PSO- 2)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Internal Test-I	30	1,2
Internal Test-II	30	3,4,5
Average of the two internal tests shall be taken for 30 marks.		
Other Components		
Quiz	10	1,2
Mini Project	10	1,2,3,4,5
Semester End Examination (SEE)	100	1,2,3,4,5

INDUSTRIAL & ENVIRONMENTAL BIOTECHNOLOGY	
Subject Code: BTE643	**Credits: 3:0:0**
Pre requisites: Microbiology	**Contact Hours: 42L**
Course Coordinator(s): Dr. Krishna Murthy T P and Dr. Priyadarshini Dey	

Course content

UNIT-I

Introduction to Industrial Biotechnology

History and development of industrial biotechnology, Characteristics and comparison of bioprocessing with chemical processing, Biosystems for industrial products production, Isolation and improvement of industrially important biosystems, Media for industrial bioprocess, Sterilisation, Culture preservation and inoculum development, Cell growth kinetics, Biosynthetic pathways and regulation of metabolic products, Bioreactors for industrial Bioprocess. Systems, synthetic and computational biology applications in industrial biotechnology.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: History of industrial microbiology
  https://link.springer.com/article/10.1007/s00253-013-4768-2

UNIT-II

Bioprocess Technologies-I

Commodity chemicals (lactic, citric, succinic, fumaric, gluconic, itaconic, acetic and propionic, acrylic and butyric acids, propanediol, butanediol etc.), enzymes (cellulase, amylase, lipase, protease, pectinases, xylanases, laccase, restriction enzymes, therapeutic enzymes etc.), amino acids (l-lysine and l-glutamic acid), microbial cells (spirulina, yeast and algae).

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: Innovation trends in industrial biotechnology
  https://www.sciencedirect.com/science/article/pii/S0167779922000750

UNIT-III

Bioprocess Technologies-II

Vitamins, antibiotics, vaccines, interferons, monoclonal antibodies, drugs, biologics and biosimilars. Fermented foods and beverages, Functional foods (Nutraceuticals, pro and prebiotics), cosmetics, flavours and fragrances, dyes and pigments, biosurfactants, biopesticides and biofertilisers. Extremophiles and mixed cultures in industrial bioprocess.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: Sustainable Industrial Biotechnology https://www.sciencedirect.com/science/article/pii/S0167779919300782

UNIT-IV

Environmental Biotechnology

Sources of pollution, wastewater treatment-characteristics and treatment strategies (primary, secondary and tertiary treatment), solid waste management, bioremediation, biotransformation and biodegradation, biomining & biohydrometallurgy, Heavy metal and oil spill bioremediation, biosensors in pollution monitoring and control, national and international environmental policies.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: Biotechnological methods to remove microplastics https://link.springer.com/article/10.1007/s10311-022-01552-4

UNIT-V

Bioenergy and Bioplastics

Types of fuels and biofuels, generations of biofuels, feedstocks for biofuel production, bioprocess strategies for production biobutanol, bioethanol, biodiesel, biogas, biohydrogen, bioelectricity, life cycle assessment of biofuels. Biorefineries- Raw materials, technologies and products. Bioplastics-Types, production, properties and applications.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: Environmental friendly green composites https://link.springer.com/article/10.1007/s11356-022-20024-4

Text Book:

1. Murray Moo-Young (2019) Comprehensive Biotechnology, 3rd Edition, Elsevier.
2. Ashok Pandey (2016), Current Developments in Biotechnology and Bioengineering Series. Elsevier.
3. Indu Shekhar Thakur (2010) Environmental Biotechnology: Basic Concepts and Applications, I K Publishers.

References

1. Michael C. Flickinger (2013) Upstream Industrial Biotechnology, John Wiley & Sons, Inc.
2. Wittmann C et al. (2017) Industrial Biotechnology: Microorganisms & Products and Processes, John Wiley & Sons, Inc.
3. Das, D., & Pandit, S. (2021). Industrial Biotechnology. CRC Press.

4. Hans-Joachim Jördening and Josef Winter (2004), Environmental Biotechnology Concepts and Applications, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim
5. Gareth G. Evans, Judy Furlong (2011) Environmental Biotechnology: Theory and Application, John Wiley & Sons, Inc.
6. Sibi, G. (2022). Environmental Biotechnology: Fundamentals to Modern Techniques. CRC Press.
7. Rittmann, B. E., & McCarty, P. L. (2020). Environmental biotechnology: principles and applications, 2nd Edition, McGraw-Hill Education.

Course Outcomes (COs):

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

1. Articulate the processes involved in bioproduct manufacturing and outline methods to advance modern biotechnological practices. (PO-2, 3; PSO-2)
2. Choose appropriate microbiological processes and manage them effectively to manufacture industrially significant products. (PO-2, 3, 4; PSO-2)
3. Utilize bioprocess technology in the production of significant health-beneficial products. (PO-2, 3, 4; PSO-2)
4. Employ microbial technology in bioremediation and bioleaching processes to solve environmental challenges. (PO-2, 4, 6; PSO-3)
5. Critically assess and contrast various biofuels, microbial fuel cells, and biodegradable plastics to understand their efficiencies and limitations. (PO-2, 4, 6; PSO-3)

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. Environmental Biotechnology: https://archive.nptel.ac.in/courses/102/105/102105088/
7. Environmental Chemistry and Microbiology: https://archive.nptel.ac.in/courses/102/105/102105087/
8. Environmental Remediation of Contaminated Sites: https://archive.nptel.ac.in/courses/105/107/105107181/

Course Assessment and Evaluation:

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

BIOMATERIALS AND TISSUE ENGINEERING	
Subject Code: BTE644	**Credits: 3:0:0**
Pre requisites: None	**Contact Hours: 42L**
Course Coordinator(s): Dr. Roshni Ramachandran	

Course content

UNIT-I

Introduction to Biomaterials

Introduction to basic concepts of materials science, need and scope for biomaterials and biomedical devices, historical development in biomaterials, classes and properties of materials used in biology: 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://archive.nptel.ac.in/courses/102/106/102106057/ https://archive.nptel.ac.in/courses/102/106/102106057/https://in.video.search.yahoo.com/search/video?fr=mcafee&ei=UTF-8&p=Introduction+to+Biomaterials&type=E211IN826G0#id=1&vd=9b1a2c66d3187953874542a1eecd32d6&action=click

UNIT-II

Characterization of Biomaterials

Physical and chemical characterization (Microstructural characterization, scanning probe microscopy, XRD, FTIR, DLS technique, contact angle measurement, mercury intrusion porosimetry, gas adsorption measurements), mechanical characterization (measurement of load and deformation), surface characterization (XPS, SIMS, MALDI MS, IR, Raman, UV spectroscopy, microscopy, profilometry), *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://publications.iitm.ac.in/publication/physical-and-chemical-characterization-of-biomaterials https://in.video.search.yahoo.com/search/video?fr=mcafee&ei=UTF-8&p=Characterization+of+Biomaterials+videos&vm=r&type=E211IN826G0#id=30&vid=514424f8e97dd029d90e035714d0b467&action=view

UNIT-III

Concept of Biocompatibility

Fundamentals of human biology and anatomy: cell, tissues and systems. Tissue-biomaterial interactions: interaction between the biomaterial surface and the tissue, effect of biomaterials on cells, effect of biomaterials on the biological tissues, responses of the body to implantation. Biocompatibility and hemocompatibility. Sterilization of biomaterials: High-temperature sterilization, ethylene oxide, radiations, low-temperature plasma, ozone and filter sterilization. Degradation of polymeric materials (environmental ageing, oxidation, photoinduced degradation, pyrolysis, enzymatic, bacterial & chemical attack, mechanical degradation etc.,), metallic materials and ceramic biomaterials.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links:https://www.sciencedirect.com/book/9780081029671/handbook-of-biomaterials-biocompatibility
  https://in.video.search.yahoo.com/search/video?fr=mcafee&ei=UTF-8&p=biocompatibility+of+biomaterials&type=E211IN826G0#id=2&vid=4469 7c8554a78b6adca20d29c66b0d09&action=click

UNIT-IV

Tissue Engineering and Regenerative Medicine

Basic definition of tissue engineering; current scope of development; use in therapeutics. Tissue development and organisation. Stem cells (embryonic), Stem cells (adult). Introduction to cell adhesion and migration. 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 case studies: artificial skin, artificial blood vessels, artificial pancreas, artificial liver, regeneration of bone, muscle, nerve regeneration. Regenerative medicine using cells and bioactive factors.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links: https://link.springer.com/book/10.1007/978-3-540-77755-7
- https://in.video.search.yahoo.com/search/video?fr=mcafee&ei=UTF-8&p=tissue+engineering+and+regenerative+medicine+video&vm=r&type=E211IN826G0#id=2&vid=11cc22ec58d5ad5274c1045aa7f5d013&action=click

UNIT-V

Clinical & Regulatory Aspects of Engineered Tissues

Tissue Engineering of Skin, Bone Tissue Engineering, Cartilage Tissue Engineering, Neuronal, Tissue Engineering, Cardiovascular Tissue Engineering, Musculoskeletal

Tissue Engineering, (tendon/ligament/muscle), Adipose Tissue Engineering. Tissue engineered therapies. Introduction, FDA Regulation, Regulation of Pharmaceutical / Medical Human Tissue Products in Europe, Regulation of Pharmaceutical / Medical Human Tissue Products in Japan, Other considerations Relevant to Engineered Tissues.

- Pedagogy/Course delivery tools: Chalk and talk and Power point presentation
- Links:https://www.oulu.fi/spareparts/ebook_topics_in_t_e_vol4/abstracts/hellman.pdf

Text Books:

1. Ratner, B. D., Hoffman, A. S., Schoen, F. J., & Lemons, J. E. (2013). Biomaterials Science: An Introduction to Materials in Medicine, 3rd Edition. Elsevier.
2. Bandyopadhyay, A., & Bose, S. (Eds.). (2013). Characterization of biomaterials. Newnes.

Reference Books

1. Tanzi, M. C., Farè, S., & Candiani, G. (2019). Foundations of Biomaterials Engineering. Academic Press.
2. Dos Santos, V., Brandalise, R. N., & Savaris, M. (2017). Engineering of biomaterials. Berlin, Germany: Springer.
3. Reis, R. L. (2019). Encyclopedia of tissue engineering and regenerative medicine. Academic Press.
4. John P. Fisher, AG Mikos & Joseph D. Bronzino (2007) Tissue Engineering, CRC Press.
5. Channarayappa (2010) Cell Biology: Universities Press (India) Pvt Ltd.
6. Patrick CW, Mikos AG, McIntire LV (1998) Frontiers in Tissue Engineering, Pergamon Press.

Web links and Video Lectures (e-Resources):

1. https://home.iitk.ac.in/~kbalani/doc/Introduction_to_Biomaterials.pdfhttps://home.iitk.ac.in/~kbalani/doc/Introduction_to_Biomaterials.pdf
2. https://www.researchgate.net/publication/327732057_Handbook_of_Materials_Characterization
3. https://in.video.search.yahoo.com/search/video?fr=mcafee&ei=UTF-8&p=biocompatibility+of+biomaterials&type=E211IN826G0#id=4&vid=ea8a6f976dcc1073860367fd1b6a0974&action=view

4. https://in.video.search.yahoo.com/search/video?fr=mcafee&ei=UTF-8&p=tissue+engineering+and+regenerative+medicine+video&vm=r&type=E211IN826G0#id=4&vid=b443367f188642199550be5423d209bc&action=click
5. https://www.cirm.ca.gov/sites/default/files/files/funding_page/FDA_Product_Development_TissueEngineering1009_0.pdf

Course Outcomes (COs):

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

1. Understand the need and scope of biomaterials in modern-day medicine (PO-1,2; PSO-1)
2. Describe the physical, chemical, mechanical and biological properties of natural and synthetic biomaterials (PO-1,2; PSO-1)
3. Analyze the significance of biocompatibility, hemocompatibility of the materials used in medicine (PO-1,2; PSO-1)
4. Apply the knowledge of biomaterials in tissue engineering and regenerative medicine (PO-1,2,3,8; PSO-1,2) .
5. Integrate the knowledge of clinical and regulatory aspects on different engineered tissues in pharmaceutical and tissue products. (PO-1, 2, 3, 4, 5, 6, 9; PSO-3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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 (SEE)	100	CO1, CO2, CO3, CO4, CO5

UPSTREAM PROCESS TECHNOLOGY LAB	
Subject Code: BTL65	**Credits: 0:0:1**
Pre requisites: Microbiology & Fundamentals of Biochemical Engineering	**Contact Hours: 14P**
Course Coordinator(s): Dr. Priyadarshini Dey & Dr. T P Krishna Murthy	

LIST OF EXPERIMENTS

1. Media formulation and sterilization methods for thermostable and thermolabile media constituents
2. Development of inoculum: single stage and multistage
3. Assessing the growth kinetics and stoichiometry of *E. coli*
4. Evaluation of monad growth kinetic parameters for Escherichia coli
5. Batch Anaerobic Fermentation-Production of ethanol by *Saccharomyces cerevisiae*
6. Batch Aerobic Fermentation- Citric acid production using *Aspergillus niger*
7. Continuous fermentation-vinegar production using immobilized *Acetobacter* sp.
8. Production and quantification Single Cell Protein (SCP) from *Spirulina*
9. Estimation of ethanol and citric acid from fermentation broth
10. Batch cultivation of *E. coli/Saccharomyces cerevisiae/algae* in a bioreactor
11. Isolation and screening auxotrophic mutants-Replica plating method
12. Organ culture/node/internodes/leaf
13. Callus induction techniques (Demo)
14. Production of plant secondary metabolites in a bioreactor (Demo)

Any 12 experiments must be performed.

Reference Books:

1. Michael C. Flickinger (2013) Upstream Industrial Biotechnology, John Wiley & Sons, Inc.
2. Liu S (2012) Bioprocess Engineering: Kinetics, Sustainability, and Reactor Design. 2nd Edition, Elsevier

Web links and Video Lectures (e-Resources):

1. Bioreactor basics
2. Development of Mathematical Model

Course Outcomes (COs):

Upon completion of the course, students will be equipped to:

1. Implement media preparation and optimization protocols to cultivate specific microbial strains. (PO1,2,9; PSO-2)
2. Assess and interpret the key parameters affecting microbial growth in controlled environments. (PO4,5,6,10; PSO-2)
3. Execute protocols to manufacture industrially significant microbial products and critically evaluate their yield and quality. (PO1,4,6,10; PSO-2)
4. Integrate biochemical and microbiological principles to formulate efficient upstream process technologies. (PO1,2,6,8; PSO-2)
5. Apply and innovate techniques for the scale-up of microbial cultures in fermenters to meet industrial demands. (PO2,4,5,6; PSO-2)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Weekly evaluation of laboratory manuals/ reports after the conduction of every experiment	30	CO1, CO2, CO3, CO4, CO5
Practical test	20	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE)	50	CO1, CO2, CO3, CO4, CO5

BIOKINETICS AND BIOREACTION ENGINEERING LAB	
Subject Code: BTL66	**Credits: 0:0:1**
Pre requisites: Biochemical Engineering Lab	**Contact Hours: 14P**
Course Coordinator(s): Dr. T P Krishna Murthy & Dr. Gokulakrishnan M	

LIST OF EXPERIMENTS

1. Determination of amylase/urease activity plant sources
2. Determination of Michaelis Menten parameters for amylase/urease
3. Effect of temperature & pH on amylase/urease activity
4. Effect of inhibitors on amylase/urease activity
5. Immobilized enzyme systems: Kinetics and Mass transfer studies
6. Basics of Bioreactors: Layout, Instrumentation, and SOP
7. Analysis of batch and mixed/plug flow bioreactor
8. RTD studies of plug flow/mixed flow bioreactor
9. Calibration of DO, pH and Temperature probes in a bioreactor
10. Determination of K_La by Dynamic/Sulphite oxidation method
11. Estimation of mixing time and power number in a batch bioreactor
12. Dynamics of first-order control systems
13. Dynamics of second-order control systems
14. Characteristics of PID controller

Any 12 experiments must be performed.

Reference Books:

1. Das, D., & Das, D. (2021). Biochemical Engineering: A Laboratory Manual. CRC Press.
2. Lasseter, B. F. (2019). Biochemistry in the lab: a manual for undergraduates. CRC Press.
3. Seborg, D. E., Edgar, T. F., Mellichamp, D. A., & Doyle III, F. J. (2016). Process dynamics and control. John Wiley & Sons.

Web links and Video Lectures (e-Resources):

1. Biochemistry Virtual Lab II: https://vlab.amrita.edu/?sub=3&brch=64
2. Process Control, Reaction Engineering and Unit Operations Lab: https://uorepc-nitk.vlabs.ac.in/
3. Bioreactor Modeling and Simulation Lab: http://38.100.110.143/model/index.html

Course Outcomes (COs):

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

1. Analyze enzyme kinetics by determining amylase/urease activity and calculating Michaelis-Menten parameters. (PO – 1,2,3,4,5; PSO -1)
2. Evaluate the effects of temperature, pH, inhibitors and immobilization on amylase/urease activity. (PO – 2,3,4; PSO – 2)
3. Understand the fundamental layout, SOPs, and instrumentation of bioreactors and analyze batch and flow bioreactor dynamics. (PO – 2,3,4; PSO – 2)
4. Apply calibration techniques for DO, pH, and temperature probes and evaluate K_La, mixing time, and power number in bioreactors. (PO – 3,9; PSO – 3)
5. Analyze the dynamics of first and second-order control systems and evaluate the operational characteristics of PID controllers. (PO – 3,5; PSO – 3)

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 50 Marks		
Assessment tool	**Marks**	**Course outcomes attained**
Weekly evaluation of laboratory reports after the conduction of every experiment.	30	CO1, CO2, CO3, CO4, CO5
Practical test	20	CO1, CO2, CO3, CO4, CO5
Semester End Examination (SEE)	50	CO1, CO2, CO3, CO4, CO5

BIOLOGY FOR ENGINEERS	
Subject Code: BT0E01	**Credits: 3:0:0**
Pre requisites: None	**Contact Hours: 42L**
Course Coordinator(s): Dr. Krishna Murthy T P	

Course content

UNIT-I

Biomolecules and Their Applications

Carbohydrates (cellulose-based water filters, PHA and PLA as bioplastics), Nucleic acids (DNA Vaccine for Rabies and RNA vaccines for COVID-19, Forensics – DNA fingerprinting, DNA Data Storage), Proteins (Proteins as food – whey protein and meat analogues, Plant-based proteins), lipids (biodiesel, cleaning agents/detergents), Enzymes (glucose and cholesterol biosensors, enzymes in cancer therapy, enzymes in paper and leather industry, enzymes in detergents).

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Links: https://bio.libretexts.org/

UNIT-II

Human Organ Systems and Bio Designs-I

Brain as a CPU system (architecture, CNS and Peripheral Nervous System, signal transmission, EEG, Robotic arms for prosthetics. Engineering solutions for Parkinson's disease). Eye as a Camera system (architecture of rod and cone cells, optical corrections, cataract, lens materials, bionic eye). Heart as a pump system (architecture, electrical signalling - ECG monitoring and heart-related issues, reasons for blockages of blood vessels, design of stents, pacemakers, defibrillators).

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Links: https://www.britannica.com/browse/Anatomy-Physiology

UNIT-III

Human Organ Systems and Bio-Designs-II

Lungs as purification system (architecture, gas exchange mechanisms, spirometry, abnormal lung physiology - COPD, Ventilators, Heart-lung machine). Kidney as a filtration system (architecture, mechanism of filtration, CKD, dialysis systems). Muscular and Skeletal Systems as scaffolds (architecture, mechanisms, bioengineering solutions for muscular dystrophy and osteoporosis).

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Links: https://www.britannica.com/browse/Anatomy-Physiology

UNIT-IV

Nature-Bioinspired Materials and Mechanisms

Echolocation (ultrasonography, sonars), Photosynthesis (photovoltaic cells, bionic leaf). Bird flying (GPS and aircraft), Lotus leaf effect (Super hydrophobic and self-cleaning surfaces), Plant burrs (Velcro), Sharkskin (Friction reducing swimsuits), Kingfisher beak (Bullet train). Human Blood substitutes - hemoglobin-based oxygen carriers (HBOCs) and perfluorocarbons (PFCs).

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Links: https://biomimicry.org/

UNIT-V

Trends in Bioengineering

Bioprinting techniques and materials, 3D printing of ear, bone and skin. 3D printed foods. Electrical tongue and electrical nose in food science, DNA origami and Biocomputing, Bioimaging and Artificial Intelligence for disease diagnosis. Self-healing Bioconcrete (based on bacillus spores, calcium lactate nutrients and biomineralization processes), Self-cooling buildings and Bioremediation and Biomining via microbial surface adsorption (removal of heavy metals like Lead, Cadmium, Mercury, and Arsenic).

- Pedagogy/Course delivery tools: Chalk and talk and PowerPoint presentation
- Links: https://www.ibiology.org/

Text Books:

1. Peter Raven, George Johnson, Kenneth Mason, Jonathan Losos, Tod Duncan. Biology. 12th Edition, 2020, McGraw-Hill Education.
2. Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Dobbs Ferry, Jane B. Reece. Campbell Biology. 11th Edition, 2020, Pearson Education Ltd.
3. Benyus, J. M. (2021). Biomimicry: Innovation inspired by nature). New York: Morrow.

References:

1. Human Physiology, Stuart Fox, Krista Rompolski, McGraw-Hill eBook. 16th Edition, 2022
2. Biology for Engineers, Thyagarajan S., Selvamurugan N., Rajesh M.P., Nazeer R.A., Thilagaraj W., Barathi S., and Jaganthan M.K., Tata McGraw-Hill, New Delhi, 2012.
3. Biology for Engineers, Arthur T. Johnson, CRC Press, Taylor and Francis, 2011

4. Biomedical Instrumentation, Leslie Cromwell, Prentice Hall 2011.
5. Biology for Engineers, Sohini Singh and Tanu Allen, Vayu Education of India, New Delhi, 2014.
6. Biomimetics: Nature-Based Innovation, Yoseph Bar-Cohen, 1st edition, 2012, CRC Press.
7. Bio-Inspired Artificial Intelligence: Theories, Methods and Technologies, D. Floreano and C. Mattiussi, MIT Press, 2008.
8. Bioremediation of heavy metals: bacterial participation, by C R Sunilkumar, N Geetha A C Udayashankar Lambert Academic Publishing, 2019.
9. 3D Bioprinting: Fundamentals, Principles and Applications by Ibrahim Ozbolat, Academic Press, 2016.
10. Electronic Noses and Tongues in Food Science, Maria Rodriguez Mende, Academic Press, 2016
11. Silverthorn, D. U. (2018). Human Physiology: An Integrated Approach, Global Edition. Pearson.

Course Outcomes (COs):

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

1. Evaluate the practical applications of carbohydrates, nucleic acids, proteins, lipids, and enzymes in industries like healthcare, energy, and manufacturing (PO: 1, 4, 6, 11).
2. Analyse the engineering parallels of the brain, eye, and heart, understanding their architecture and functional similarities to technical systems (PO: 1, 2, 5, 9).
3. Apply understanding of lungs, kidneys, and muscular and skeletal systems to interpret medical technologies like spirometry, dialysis, and bioengineering solutions (PO: 1, 3, 6, 7).
4. Synthesize knowledge of bio-inspired designs to propose innovative solutions in fields such as robotics, energy conversion, and material science (PO: 1, 3, 5, 10).
5. Evaluate and apply cutting-edge bioengineering techniques like 3D bioprinting, DNA origami, and bio-imaging in solving real-world problems (PO: 1, 4, 5, 11, 12).

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/121106008
2. https://ocw.mit.edu/courses/20-020-introduction-to-biological-engineering-design-spring-2009

3. https://ocw.mit.edu/courses/20-010j-introduction-to-bioengineering-be-010j-spring-2006
4. https://www.coursera.org/courses?query=biology
5. https://onlinecourses.nptel.ac.in/noc19_ge31/preview
6. https://www.classcentral.com/subject/biology
7. https://biomimicry.org/
8. https://www.biomimicry.net/
9. https://www.ibiology.org/
10. https://www.ibiology.org/biology-techniques/

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE): 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 (SEE)	100	CO1, CO2, CO3, CO4, CO5