GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Science (Industrial Biotechnology)

Level: PG

Course / Subject Code: IB02001021

Course / Subject Name : Downstream Processing

1. Learning Outcomes

Learning Outcome Component	Learning Outcome (Learner will be able to)
Theoretical and practical understanding of downstream processing	• Discuss cell separation, filtration and treatment of product by chemical, physical and biological means. • Various techniques involved in the purification process.
Give an insight in applicability of downstream processing in different fields of industry	• Describe about recovery, extraction and purification of biosynthetic products in biotech industries.
Effective Communication	• Communicate concepts and ideas effectively.
Professional & Ethical Behaviour	• Transparency, honesty and ethical reasoning in handling biomolecules and product processing.

LO – PO Mapping: Correlation Levels:
1 = Slight (Low); 2 = Moderate (Medium); 3 = Substantial (High), "-"= no correlation

Sub Code: 1320102	PO1	PO2	PO3	PO4	PO5	PO6	PO7
LO1:Theoretical and practical understanding of downstream processing	3	2	3	2	3	3	2
LO2:Give an insight in applicability of downstream processing in different fields of industry	3	3	3	2	2	3	2
LO3: Effective communication	2	3	2	2	3	3	2
LO4: Professional & Ethical Behaviour	2	2	3	2	3	2	3

2. Course Duration: The course duration is 45 sessions of 60 minutes each.

3. Course Contents:

Module No:	Module Content	No. of Sessions	70 Marks (External Evaluation)
1	**Screening and Design purification strategies** Overview of down-stream processing, Establishment of design space for biopharmaceutical process, High-throughput process development, Media selection in ion-exchange chromatography in single microplate, high-throughput screening of dye- ligand for chromatography.	9	10

2	**Low-resolution protein purification methods** Aqueous two phase partitioning systems, A platform for isolation of process related impurities from therapeutic proteins, Simultaneous purification refolding of protein by affinity precipitation and macro (Affinity ligand)-facilitated three-phase partitioning (MLFTPP), Co-expression and co-purification of antigen-antibody complexes in bacterial cytoplasm and periplasm, immunoglobulin purification by caprylic acid; Filtration, chromatography (comparison), rationale of choosing between quality and cost of different products.	9	14
3	**Protein purification and characterization** Introduction, initial recovery of proteins, removal of whole cells and cell debris, concentration and primary purification, protein inactivation and stabilization, protein characterization.	7	12
4	**Large scale protein purification** Some general principles, range and medical significance of impurities potentially present in protein based therapeutic products, labelling and packing of finished products.	5	8
5	**Animal based products** General DSP, Case studies of: monoclonal antibodies, Tissue plasminogen activator, insulin, erythropoietin.	5	10
6	**Plant based products** General DSP, Case studies of: shikonin, Protein extracts from Seed material and green tissues.	5	8

7	**Microbial based products** General DSP, Case studies of: lipase, cellulose, amylase, horseradish peroxidase, subtilisin, ethanol, citric acid, xanthan gum.	5	8
9	**Practicals** 1. Conventional filtration 2. Centrifugation in batch and continuous centrifuge 3. Cell disruption 4. Protein precipitation and its recovery 5. Ion-exchange chromatography 6. Membrane based filtration-ultra, filtration in cross flow modules and micro filtration 7. Adsorption process in batch and continuous mode.	-	(30 marks)

4. Pedagogy:

- ICT enabled Classroom teaching
- Practical / live assignment
- Interactive classroom discussions

5. Evaluation:
Students shall be evaluated on the following components:

	Internal Evaluation	**(Internal Assessment – 20 Marks)**
A	• Continuous Evaluation Component	10 marks
	• Class Presence	5 marks
	• Record maintenance	5 marks
B	**Mid-Semester Examination**	**(Internal assessment-30 Marks)**
C	**End-Semester Examination**	**(External assessment-70 Marks)**

6. Reference Books:

No	Author	Name of the Book	Publisher	Year of Publication / Edition
1	Nikolaos E. Labrou	Protein Downstream Processing: Design, Development and Application of High and	Humana Press	Latest Edition

		Low Resolution Methods in Molecular Biology		
2	Gary Walsh	Proteins: Biochemistry and Biotechnology	Wiley Blackwell	2nd Edition
3	Desai, M.	Downstream Processing of Proteins: Methods and Protocols	Humana Press	Latest Edition

Note: Wherever the standard books are not available for the topic appropriate print and online resources, journals and books published by different authors may be prescribed.

7. List of Journals/Periodicals/Magazines/Newspapers / Web resources, etc

- https://onlinelibrary.wiley.com/doi/full/10.1002/elsc.201600033
- https://www.sintef.no/en/expertise/sintef-industry/biotechnology-and-nanomedicine/downstream-processing-product-isolation-purificati/
- https://pubmed.ncbi.nlm.nih.gov/25922318/
- https://fenix.tecnico.ulisboa.pt/downloadFile/563345090412611/Dissertacao_DSP%20viruses.pdf

Course Outcomes:

On completion of this course, students should be able to:

• Identify and design relevant unit operations for recovery of biological products