## DOWNSTREAM PROCESSING

| Semester | Subject Code | Category | Lecture | | Theory | | P | C |
|---|---|---|---|---|---|---|---|---|
| III | 21CPBT3B | Core - VIII | 5 hrs per week | 75 | 5 hrs per week | 75 | 0 | 5 |

**COURSE OBJECTIVE:** In this course, students will

- Understand the principles of downstream processing including product separation using physical methods, chemical methods and recovering of products by extraction, filtration, and product purification by chromatographic techniques and product formulation.

**COURSE OUTCOMES:** Up on successful completion of course, students will be able to

| CO NUMBER | CO STATEMENT | KNOWLEDGE LEVEL ( K1-K6) |
|---|---|---|
| CO1 | Classify different cell disruption methods and pre-treatment techniques. | K2 |
| CO2 | Demonstrate different physical methods of product separation. | K3 |
| CO3 | Distinguish various techniques in product recovery and develop new tools for product recovery. | K4 &K5 |
| CO4 | Evaluate the recovered products after purifying products using chromatographic techniques. | K6 |
| CO5 | Formulate the products by crystallization and lyophilisation. | K5 |

**Knowledge level:** K1- Remember; K2- Understand; K3- Apply; K4- analyze; K5-Synthesize; K6- Evaluate.

**Mapping with Programme Outcomes**

| COS | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | S | S | M | M | M | M |
| **CO2** | S | S | M | M | M | M |
| **CO3** | S | S | S | M | M | M |
| **CO4** | M | M | M | S | S | S |
| **CO5** | M | M | M | S | S | S |

S-strong; M- medium; L-low

**UNIT I INTRODUCTION TO DOWNSTREAM PROCESSING 13 Hours**

Introduction to Downstream processing principles, Characteristics of bio molecules and bioprocesses, Cell disruption for product release and its types, Mechanical methods of cell disruption, Enzymatic methods of cell disruption, Chemical methods of cell disruption, Pre-treatment of bio products, Stabilization of bio products.

**UNIT II PHYSICOCHEMICAL METHODS OF SEPARATION 15 Hours**

Removal of insoluble Products, Physical methods: Introduction to filtration, Continuous rotary filters , microfiltration, membrane modules, rotary drum filters, Scale up of centrifugation, Centrifugal filtration .Applications of Centrifugation. Chemical methods: Electrolysis, Bioleaching.

**UNIT III PRODUCT RECOVERY 15 Hours**

Introduction to adsorption and adsorbents, Batch adsorption, Adsorption in continuous and fixed beds, Introduction to liquid-liquid extraction, Different types of extractions, Aqueous two-phase extraction, Introduction to membrane separation techniques, Ultra filtration, reverse osmosis, Dialysis, Introduction to precipitation and its types, Large scale precipitation.

**UNIT IV PRODUCT PURIFICATION 16 Hours**

Chromatography – principles, instruments and practice, adsorption, reverse phase, ion-exchange Chromatography, size exclusion Chromatography, hydrophobic interaction, and bioaffinity and pseudo affinity chromatographic techniques

**UNIT V PRODUCT FORMULATION 16 Hours**

Product formulation :Introduction to polishing steps, Crystallization basic concepts, Crystallization types and equipments, Recrystallization, Basics of drying and its types, Adiabatic drying, Lyophilization.

**Distribution of Marks:** Theory 80% and Problems 20%

**TEACHING METHODOLOGY**

- Class room teaching
- Assignments
- Discussions
- Home work
- PPT presentations
- Seminars
- Models/Charts

**TEXT BOOKS:**

| S.NO. | AUTHORS | TITLE | PUBLISHERS | YEAR OF PUBLICATION |
|---|---|---|---|---|
| 1. | Belter P.A., E.L. Cussler | Bio separations-Downstream | Wiley Interscience | 1988 |

| | | | | |
|---|---|---|---|---|
| | and Wei-Houhu | Processing for Biotechnology | | |
| 2. | JenKins R.O. | Product Recovery in bioprocess Technology-Biotechnology by Open Learning series | Butterworth-Heinemann | 1992 |
| 3. | Bell D.J | Downstream Processing | Springer-Verlag | 1983 |
| 4. | Bell D.J &Dunnill | Downstream Processing | Springer | 2013 |
| 5. | Mohamed A. Desai | Downstream Processing of Proteins | Springer Science & Business media | 2000 |

**REFERENCE BOOKS:**

| S.NO. | AUTHORS | TITLE | PUBLISHERS | YEAR OF PUBLICATION |
|---|---|---|---|---|
| 1. | J.C. Janson and L. Ryden | Protein Purification – Principles, High Resolution Methods and Applications | VCH Pub | 1989 |
| 2. | R.K. Scopes | Protein Purification – Principles and Practice | Narosa Pub | 1994 |
| 3 | B. Sivasanker | Bioseperations-Principles and Techniques | Prentice –Hall of India | 2005 |
| 4. | Roger G.Harrison, Paul Todd | Bioseparations Science and Engineering | Oxford University Press | 2006 |
| 5. | D. G. Rao | Introduction to Biochemical Engineering | Tata McGraw-Hill Education | 2005 |

**WEB SOURCES**

1. https://www.slideshare.net/saileegurav/downstream-processing-30441992
2. https://nptel.ac.in/courses/102106022/
3. http://www2.che.nthu.edu.tw/~biohu/download/handouts/2015%20Introduction%20to%20Biotechnology/Chap9%20Downstream%20processing.pdf
4. https://www.youtube.com/watch?v=Uut1cUs6GpA
5. http://biomanufacturing.org/uploads/files/92268253567700668-chapter-11-restricted.pdf

**Syllabus Designer:**

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  Assistant Professor