

BCH 601

Course Main Objective(s):

1. Equip students with in-depth knowledge of advanced methods and techniques for separating and purifying biomolecules.
2. Develop expertise in designing and applying biochemical sensors for analytical and diagnostic purposes.
3. To learn biochemical fuel cells' principles and practical applications in energy and healthcare systems.
4. To understand bioremediation and biodegradation strategies for environmental sustainability.
5. To learn about industrial carbohydrate applications, including their use in food, pharmaceuticals, and materials science.
6. Provide insights into the biochemical roles and identification of eicosanoids, heat shock proteins, and interferons.
7. To study the principles and applications of enzyme immobilization in bioprocessing and industrial catalysis.
8. To foster expertise in biochemistry's practical and industrial applications, preparing students to address real-world challenges in research and industry.

No	List of Topics	Contact Hours
1.	Principles and techniques for the separation and purification of biomolecules.	3
1.	Biochemical sensors for diagnostic and industrial purposes.	3
1.	Biochemical fuel cells, including their mechanisms, designs, and potential for sustainable energy applications.	3
1.	Biochemical basis of bioremediation and biodegradation for environmental applications.	4
1.	The industrial applications of carbohydrates in food, pharmaceuticals, and material science.	3
1.	Eicosanoids, heat shock proteins, and interferon identification.	4
1.	Applications of enzyme immobilization.	3
1.	Biomolecular electrode technology.	3
9	Presentation skills	4
Total		30

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	1st Assessment exam		20
1.	2 nd Assessment exam		20
1.	Homework (S2)		10
1.	Oral Presentation (S4)		10
5	Final exam		40

- Biomolecules are the fundamental building blocks of life, and their interactions and functions are at the core of biological processes. They work together in complex ways to maintain the structure and function of cells and organisms.
- Understanding these biomolecules and their roles is crucial in fields like biology, biochemistry, and medicine.

(PDF) Separation Techniques of BIOMOLECULES. Available from:
https://www.researchgate.net/publication/395099449_Separation_Techniques_of_BIOMOLECULES [accessed Sep 03 2025].

Separation Techniques of Biomolecules

- Separation, as applied to chemical systems, means to part or divide a homogeneous or heterogeneous mixture or mass into components, individual units, or even into elements, separation may be performed by making use of many different methods and techniques which are based on sound fundamental chemical and physical properties.

- A separation procedure may be used for purification, qualitative identification, or qualitative determination. Many different separation methods have been known and used for along time (e.g. gravimetry) and some have been developed (eg. Gas Chromatography and Thin Layer Chromatograph
(PDF) *Separation Techniques of BIOMOLECULES*. Available from:
https://www.researchgate.net/publication/395099449_Separation_Techniques_of_BIOMOLECULES [accessed Sep 02 2025].

- The separation of biomolecules is a crucial process in biochemistry and biotechnology. It involves various techniques to separate and purify different types of biomolecules, such as proteins, nucleic acids, carbohydrates, and lipids.
- The nature of the separation process depends on the specific biomolecules you want to isolate and their physical and chemical properties. Here are some common techniques:
 1. Chromatography: This method separates biomolecules based on their affinity for a stationary phase (e.g., a column packing material) and a mobile phase (e.g., a solvent). Different types of chromatography, such as size exclusion, ion exchange, and affinity chromatography, can be used depending on the target molecule's characteristics.
 2. Electrophoresis: Electrophoresis separates biomolecules, particularly nucleic acids and proteins, by their charge and size. In gel electrophoresis, molecules move through a gel matrix under an electric field, with smaller molecules moving faster.

3. Centrifugation: Centrifugation relies on differences in density and size to separate biomolecules. Ultracentrifugation is a powerful technique for separating organelles, proteins, or other cellular components based on their density.
4. Precipitation: Biomolecules can be selectively precipitated by adding specific reagents or changing conditions such as temperature or pH. For example, salting out is used to precipitate proteins.
5. Filtration: This process separates biomolecules based on size. It's commonly used to separate particles, such as proteins or cells, from a liquid.
6. Extraction: Organic solvents or reagents can be used to extract specific biomolecules from a mixture. For instance, phenol-chloroform extraction is used for DNA isolation.
7. Ultrafiltration: This method employs semi permeable membranes with defined pore sizes to separate biomolecules based on size and molecular weight.
8. Magnetic Separation: Magnetic beads or nanoparticles can be used to selectively separate biomolecules that have been tagged with magnetic labels.

- The choice of separation technique depends on the nature of the biomolecules you're working with, their properties, and the purity required for downstream applications. Often, a combination of these techniques is used in a purification protocol to achieve the desired level of separation and purity.

Principles and Techniques for the Separation and Purification of Biomolecules

- The purification of biomolecules is a critical step in numerous scientific and industrial processes:
 - **Essential Foundation**: Underpins drug development, diagnostics, therapeutics, fundamental biochemical research
 - **Purity Matters**: Directly impacts biological function, safety profiles, and reliability of downstream applications
 - **Complex Challenges**: Navigating complex biological mixtures, low abundance and diverse physicochemical properties

Core Principles of Biomolecule Separation

Size
Molecular weight and physical dimensions
determine movement through porous
media

Hydrophobicity
Varying interactions with water and non-
polar environments



Charge

Net surface charge varies with pH, enabling
enabling separation of otherwise similar
similar molecules

Solubility

Different precipitation points in varying salt
varying salt concentrations or solvents
solvents

Affinity

Specific binding interactions with ligands,
ligands, antibodies, or substrates

No universal method exists—successful purification typically requires multi-step processes tailored to the specific biomolecule whilst maintaining
whilst maintaining stability and biological activity throughout.

Initial Steps: Extraction and Crude Fractionation

Cell Disruption Methods

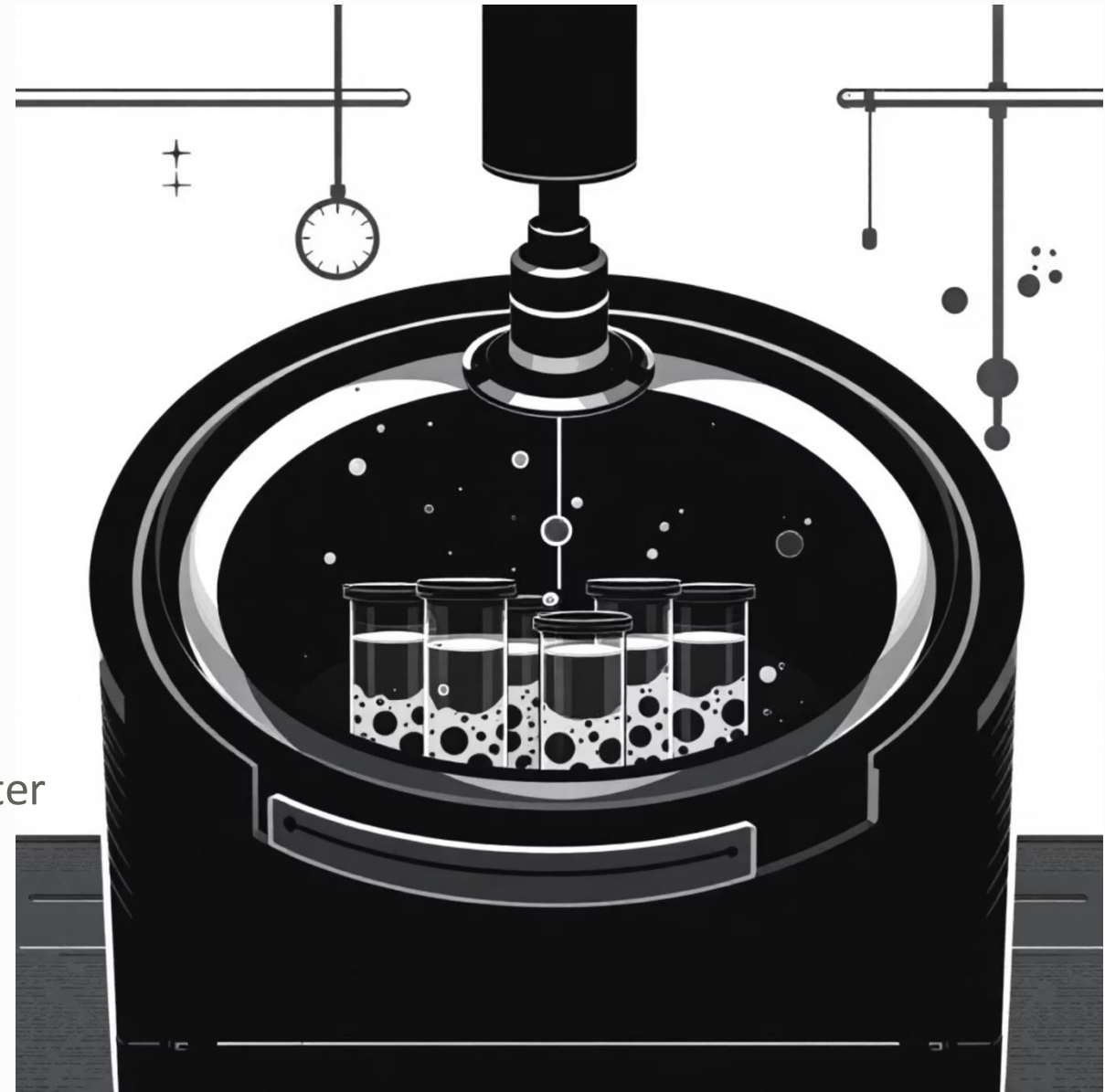
- Mechanical: sonication, homogenisation, bead milling
- Chemical: detergents, osmotic shock, solvents
- Enzymatic: lysozyme, cell wall digesters

Preserving Protein Integrity

Optimal buffers, protease inhibitors, controlled temperature, and reducing agents prevent denaturation and degradation

Initial Clarification Steps

1. Centrifugation removes cellular debris and insoluble matter
2. Filtration through membranes of decreasing pore size
3. Results in crude extract containing target biomolecule



“The future of biomolecule purification lies in miniaturisation, automation, and sustainability.”

Emerging Technologies: Microfluidics and Green Chemistry Approaches

Approaches

Microfluidic Devices

Microscale channels enable rapid, precise separations

Minimal sample volumes (nanolitres to microlitres)

Potential for parallelisation and automation

Aqueous Two-Phase Systems

Polymer/salt systems form two immiscible phases

Biomolecules partition based on surface properties

Environmentally friendly, scalable approach