



## Introduction to Industrial Biochemistry

Industrial biochemistry is a field that integrates biochemical principles with industrial processes to develop innovative, sustainable, and efficient methods for producing a wide range of products.

By applying the principles of biochemistry, which focus on the study of biological molecules and their interactions, it becomes possible to design and optimize processes ranging from pharmaceutical production to the biochemical management of waste.

This intersection between bio and industry has led to remarkable advancements, developing traditional manufacturing processes to produce Greener or more environmentally friendly, for example by minimizing pollution or using renewable resources, and more efficient technologies.

**Industrial biochemistry** focuses on production some products such as:

foods, drinks, pharmaceuticals and medical compounds e.g antibiotics, hormones, solvents, organic acids and enzymes that have direct economic values.

Industrial biochemistry, Industrial microbiology and Industrial biotechnology involve the use of microorganisms and other micro and macro-molecules purposely to achieve specific aims. Basically, it involves:

- (i) Production of new products with monetary, economy and/or social values.
- (ii) Also for purpose of improving the standard of living and that of the environment under general acceptability.

In industrial processes, microorganisms are commonly utilized due to their :

- (i) Ease of handling
- (ii) Ease to cultivation, and
- (iii) Ease to manipulation.

Typically, these microbes are first isolated from natural sources and then improved through traditional methods such as mutation and selection procedures.

Analysis of microbial cell composition has shown that more than 90% of the cell's dry weight consists of various macro and micronutrients, including carbon (C), oxygen (O), nitrogen (N), hydrogen (H), sulfur (S), potassium (K), zinc (Zn), magnesium (Mg), and nickel (Ni). Elements such as C, O, N, H, S, and phosphorus (P) are especially essential, as they are the fundamental building blocks of carbohydrates, lipids, proteins, and nucleic acids.

Potassium (K) is essential for the activity of certain enzymes, while magnesium (Mg) often functions as a cofactor for many enzymatic reactions. Sulfur (S) is required for the synthesis of sulfur-containing amino acids such as cysteine and methionine. Iron (Fe) is commonly found as a component of cytochromes, playing a key role in electron transport. Calcium ions ( $\text{Ca}^{2+}$ ) contribute to the heat resistance of bacterial endospores. Zinc ions ( $\text{Zn}^{2+}$ ) are typically located at the active sites of various enzymes, aiding in their catalytic function. Additionally, nitrogen (N) is crucial for the synthesis of amino acids and ammonia ( $\text{NH}_3$ ).

In addition to these essential elements, microorganisms also require other specific sources of nutrients or growth factors that support their development. These additional requirements can influence certain characteristics of microbial cells, including their morphology, metabolic pathways, and structural features.

For example, the presence or absence of certain vitamins, amino acids, or trace elements can affect cell shape, motility, spore formation, or biofilm production. Other compounds such as vitamins are also utilized by microbes. For instance, biotin is necessary for carboxylation of one carbon metabolism in *Leuconostoc mesenteroides* while folic acid which is for transfer of acyl group is required by *Lactobacillus casei*.

More so, thiamine (vit. B1 ) is involved in the transfer of aldehyde group in *Onchomonas mellamensis* while pantothenic acid serves as precursor of CoA in paramecium species.

### Importance & Applications:

Industrial biochemistry plays a critical role in sustainable development and the green economy. Unlike traditional chemical industries that may rely on toxic solvents and high energy input, biochemical processes are often eco-friendly, energy-efficient, and renewable.

### Applications include:

- 1- **Pharmaceuticals:** Antibiotics, vaccines, and therapeutic proteins.
- 2- **Food Industry:** Fermentation processes (e.g., yogurt, cheese, beer).
- 3- **Bioenergy:** Production of ethanol, biodiesel.
- 4- **Textiles & Leather:** Enzymatic treatments for better quality.
- 5- **Waste Management:** Bioremediation and waste recycling.

# History of Industrial Biochemistry

Industrial biochemistry, as a scientific and applied field, has evolved through several major stages—each marked by key discoveries, technological innovations, and increasing industrial demand.

## 1. Ancient Biochemical Practices (Before 1800s)

Although the term "biochemistry" wasn't used, humans have unknowingly used biochemical processes for thousands of years. Early examples include:

Fermentation of bread, beer, and wine by ancient Egyptians and Mesopotamians.

Cheese and yogurt production through natural microbial action.

Vinegar production via acetic acid bacteria.

These processes were empirical and passed down without understanding the underlying microbial mechanisms.

## 2. Birth of Microbiology and Biochemistry (1800s)

Louis Pasteur (1850s–1870s): Demonstrated that microorganisms were responsible for fermentation and spoilage. His work laid the foundation for industrial microbiology and pasteurization.

Eduard Buchner (1897): Discovered that cell-free extracts from yeast could ferment sugar into alcohol. This led to the idea that enzymes (biocatalysts) could function outside living cells—a breakthrough for enzymology and industrial applications.

## 3. Early Industrial Applications (1900–1950)

Large-scale fermentation began for products like alcohol, citric acid, and acetone.



World War I & II: Accelerated the development of microbial production of solvents and antibiotics (e.g., penicillin production during WWII became the first large-scale industrial bioprocess).

Enzyme production started to gain attention for applications in food and textile industries.

#### 4. Modern Industrial Biochemistry (1950–2000)

Advances in bioreactor design, process control, and sterilization techniques made microbial production more efficient and scalable.

Genetic engineering emerged in the 1970s:

Enabled the production of human insulin, growth hormones, and other proteins using genetically modified organisms (GMOs).

Shifted focus from natural isolates to engineered strains for higher yield and specificity.

Enzyme technology expanded into detergents, textiles, leather, and food processing.

#### 5. Recent Developments & Trends (2000–Present)

Synthetic biology allows the design of custom microorganisms for producing fuels, chemicals, and pharmaceuticals.

CRISPR and gene editing tools have revolutionized strain improvement.

Green chemistry and sustainability goals have driven demand for eco-friendly, biobased processes to replace traditional chemical methods.

Emergence of biorefineries that convert biomass into a wide range of industrial products, including biofuels, bioplastics, and biochemicals.