Describe Industrial Biotechnology

Any technology that is predominantly employed in engineering or the production of goods is referred to as industrial technology. Industrial technology is both a field of study and a vocation that calls for expertise in both business management and technology to solve problems and expedite operations.

According to Soetaert et al., industrial biotechnology is a multidisciplinary field that combines biochemistry, microbiology, molecular genetics, and process technology to develop useful processes and products using cells, enzymes, and organelles from microorganisms, animals, or plants. Microorganisms, such as bacteria, yeasts, and fungi, are particularly valuable in this technology and are utilized in fermentation processes. In natural environments, these microorganisms often don't encounter the optimal conditions for growth and product formation. However, in controlled laboratory conditions (in vitro), biotechnologists can manipulate the microbial cell environment and genetic material (DNA) to better control and direct cell metabolism during fermentation. Microorganisms are highly versatile, can use renewable resources, exhibit fast growth and reactions, and can be genetically modified, making them crucial in various sectors of industrial biotechnology.

1. Emergence of Biotechnology. (17th and 19th)

Spontaneous generation, also known as abiogenesis, was a belief that living organisms could arise spontaneously from non-living matter. This concept was prevalent for centuries and was widely accepted until the 19th century. The idea suggested that complex life forms could emerge from simple materials without the need for pre-existing life.

Spontaneous generation was challenged and eventually disproven through scientific experiments conducted in the 17th, 18th, and 19th centuries. One significant experiment was performed by Francesco Redi in 1668. Redi demonstrated that maggots found on decaying meat did not spontaneously generate but instead came from fly eggs. This experiment provided evidence against the spontaneous generation of complex organisms.

Another notable experiment was conducted by Louis Pasteur in the mid-19th century. Pasteur designed an experiment using swan-necked flasks filled with broth. He heated the flasks to kill any existing microorganisms and observed that no growth occurred in the broth, even over extended periods. This experiment demonstrated that microorganisms were not spontaneously generated but were introduced from the external environment, thus supporting the theory of biogenesis.

The experiments by Redi and Pasteur, among others, led to the rejection of spontaneous generation and the acceptance of the theory of biogenesis. This scientific understanding was a significant turning point in biology and marked the beginning of modern microbiology, where it became clear that life can only arise from pre-existing life.

1. Modern Biotechnology. (19th)
2. The field of genetics underwent a transformative phase with the development of a molecular model for DNA's structure by James Watson and Francis Crick, which was based on data from Rosalind Franklin's crystallography studies. However, the impact of this "DNA Revolution," as referred to by Hotchkiss, had a slow and gradual integration into technology, initially having minimal influence on traditional processes and products. Nevertheless, significant scientific breakthroughs and technological advancements laid the foundation for biotechnology. These advancements included the analysis of DNA, RNA, and proteins, studying their structures, synthesizing short DNA molecules, identifying and purifying DNA molecules that encode medically active proteins, introducing such DNA (including from human sources) into bacteria, and enabling protein expression in bacteria.

B. James Watson and Francis Crick discovered the structure of DNA, which changed the field of molecular biology. Their work had a big impact on biotechnology companies:

* Genetic Engineering: Their discovery helped scientists modify DNA to create new traits or products.
* Biopharmaceuticals: DNA structure understanding led to the production of therapeutic proteins and vaccines.
* Molecular Diagnostics: Their discovery improved diagnostic techniques by identifying disease-related DNA sequences.
* Genomics and Precision Medicine: Their work contributed to personalized treatments based on an individual's genetic profile.

1. Rise of Industrial Biotechnology.

The field of applied biocatalysis and industrial enzymes has a rich history of developments. Key milestones include the use of diastase in brewing (19th century), Emil Christian Hansen's enzyme preparation for cheese making (1874), and Emil Fisher's findings on enzyme specificity and "lock and key" action (late 19th century). The work of Eduard and Hans Buchner in 1897 established the chemical nature of alcohol fermentation. J.B. Sumner's work in 1926 crystallized jack bean urease and confirmed the protein nature of enzymes.

In the early 20th century, the Rohm and Haas Company was founded in Germany, and enzymatic reactions with crude enzymes such as amylase, lipase, protease, and others were described. Michaelis and Menten's kinetic studies in 1913 contributed to the understanding of enzyme action. Jokichi Takamine patented a microbial enzyme product in 1894, and the production of plant lipases and proteolytic enzymes for beer chillproofing and bread baking began.

In the 1930s, pectinases were produced for the fruit juice industry, and the enzymatic action in leather manufacturing was discovered, leading to the development of bacterial bates. Pancreatic extract and the trade name "Oropon" became successful bating agents. Large-scale submerged fermentation processes for enzymes emerged in the late 1950s, with the introduction of detergent enzymes and the use of glucoamylase for glucose production from starch.

1. Industrial Biotechnology Applications

* Biofuels: Industrial biotechnology contributed to the development of biofuels, including ethanol and biodiesel, as alternatives to fossil fuels.
* Biopharmaceuticals: Recombinant DNA technology allowed for the production of therapeutic proteins, such as insulin and vaccines, using genetically engineered organisms.
* Industrial Chemicals: Microorganisms and enzymes have been harnessed for the production of various chemicals, including organic acids, solvents, and polymers.
* Agriculture and Crop Improvement: Biotechnology has been used to develop genetically modified crops with improved traits, such as resistance to pests or tolerance to environmental conditions.

Describe the pros and cons of Industrial Biotechnology.

According to Health Care Innovators.

Pros:

* Reduced environmental impact: Industrial biotech can lessen environmental impact by substituting more environmentally friendly and sustainable manufacturing methods for conventional ones that use non-renewable resources or generate hazardous waste.
* Increased sustainability: By utilizing renewable resources and lowering waste, industrial biotech can increase the sustainability of manufacturing operations.
* Reduced animal testing: Industrial biotech can lessen the requirement for animal testing by substituting cell cultures and computer models for animal testing in drug development.
* Improved health outcomes: By creating novel disease treatments and therapies, industrial biotech can enhance health outcomes.

Cons:

* Unanticipated consequences: The usage of genetically modified organisms (GMOs) and other biotech procedures may result in unanticipated outcomes, such as the emergence of new diseases or the escalation of antibiotic resistance.
* Bio-contamination risk: The release of genetically modified organisms into the environment has the potential to contaminate unintentionally and harm the environment.
* The use of living organisms in industrial biotech presents ethical questions, particularly those pertaining to concerns for the welfare of animals.
* The patenting of biotechnological methods and products raises moral questions about who should own and manage living things.
* Technological dependence: Industrial biotech may lead to a dependence on technology and a loss of traditional knowledge and practices.

Explain how Industrial Biotechnology works in different focus area.

Importance of Industrial Biotechnology/Benefits:

Industrial biotechnology is also a factor that regularly displays notable performance advantages over traditional chemical technologies, including a greater response rate, improved product purity, improved conversion efficiency, lower energy consumption, and considerable reduction in the production of chemical waste. These elements working together have resulted in the recent strong industrial biotechnology's adoption throughout all industries chemical sector, especially fine chemicals, but the same holds true for bulk substances like fuels and polymers.

For example, some of the products today that are widely known because of the innovation in industrial biotechnology.

Vitamins:

Vitamins are important chemicals, with some requiring biotechnology for production, while others can be synthesized chemically or through a combination of chemical and biotechnological methods. Vitamin B12 is an example of a complex vitamin that can only be produced through biotechnology. However, simpler vitamins can be synthesized using both chemical and biotechnological routes.

An illustration of this is the synthesis of vitamin B2 (riboflavin), which used to involve a combination of fermentation with Bacillus bacteria to produce the building block D-ribose, followed by a series of chemical reactions to obtain riboflavin. This process required eight steps and employed both chemical and biotechnological methods. However, recent advancements have enabled the complete biotechnological synthesis of riboflavin in a single fermentation step using bacteria, yeast, or fungi.

Pharmaceutical:

Industrial biotechnology has made significant strides in the fine chemical and pharmaceutical sectors, comprising 15% of the market. Antibiotics, valued at around 20 billion euros globally, are mainly produced through fermentation processes using selected microorganisms due to their complex structures. Biotechnological methods are replacing chemical modifications for improved effectiveness, providing economic and ecological advantages.

In the pharmaceutical sector, the synthesis of Captopril™, an ACE inhibitor for high blood pressure, involves fermentation to produce the building blocks D-β-hydroxy-isobutyric acid and L-proline. These building blocks are then chemically linked to form Captopril™. In the fine chemical sector, biotechnological routes have been developed, such as the conversion of 3-cyanopyridine to nicotinamide (vitamin B3) and related compounds. Enzymatic hydrolysis with nitrile hydratase from Rhodococcus bacteria or bioconversion with living bacterial cells are employed, resulting in highly specific reactions and nearly quantitative yields.

Bio-energy:

Industrial biotechnology plays a crucial role in converting biomass into usable fuel, particularly in the form of bio-ethanol. While energy content is important, the value of a fuel also depends on its physical form and ease of use. Bio-ethanol, produced from sources like sugar beet, offers a compact and user-friendly liquid fuel that can be easily mixed with regular gasoline and used without requiring engine modifications. This aligns well with the existing concept of mobility based on liquid fuels and gasoline stations. These conversion processes are carried out in biorefineries, utilizing industrial biotechnological processes.

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Describe some of the application areas of Industrial Biotechnology.

Industrial biotechnology is applied in a variety of fields to provide effective and sustainable solutions:

* Biofuels: Using renewable resources like plants, biotechnology enables the production of fuels like ethanol and biodiesel. To lessen reliance on fossil fuels, microorganisms are used to transform these sources into useful fuels.
* Bioplastics: Using renewable resources, biotechnology enables the manufacturing of plastics that are environmentally benign. Plant-based materials can be transformed into biodegradable plastics as an alternative to conventional plastics by microorganisms or enzymes.
* Enzymes: Catalysts in nature that quicken chemical reactions are known as enzymes. In industries like food, textiles, and biofuel production, biotechnology uses isolated or altered enzymes to improve industrial processes, decompose materials, or produce useful molecules.
* Agricultural Biotechnology: Biotechnology is applied to the production of genetically engineered crops with improved characteristics, such as pest resistance or stress from the environment. It also aids in the creation of microorganism-based biofertilizers and biopesticides.
* Pharmaceuticals and biologics: Biotechnology is essential for the creation of sophisticated biological substances and medications. Therapeutic proteins, antibodies, vaccinations, and other vital medical goods are created using genetically engineered organisms like bacteria or mammalian cells.

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