

BIOTECHNOLOGY
DR. NAZAR A. HAMZAH

Biotechnology: A Brief Introduction

Plant, animal and microbes have been used by humans for nutrition and development of products for consumption such as bread. Understanding of physical phenomenon has allowed the invention of different types of electronic gadgets, machines, devices and altogether these have been used to increase the efficiency of human activities. Technological advancement has also allowed him to exploit plant, animal and microbial wealth to provide products of commercial or pharmaceutical importance. All these activities (research and development) fall under the big umbrella of biotechnology. In simpler word, Biotechnology is the summation of activities involving technological tools and living organism in such a way that it will enhance the efficiency of the production. The ultimate goal of this field is to improve the product yield from living organism either by employing principles of bio-engineering/bio-process technology or by genetically modifying the organisms. For example, production of bread or other bakery items from wheat flour after adding yeast as fermenting organism (Figure 1.1). From ancient times wheat flour has been used to prepare bread but yeast has been added to the wheat flour to make it porous by CO₂ generation during fermentation. Since then this process has been very popular in bakery industry and is responsible for preparation of bread, cakes, pizza, etc.

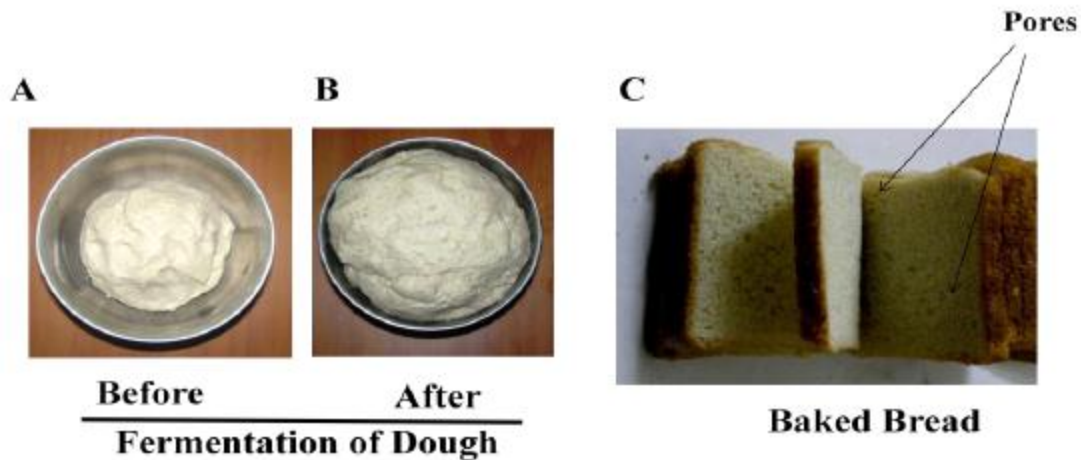


Figure 1.1: Making of Bread from wheat flour. (A) & (B) Dough before and after fermentation. (C) Cross section of baked Bread.

Note the increase in volume of the dough after fermentation and formation of pores in cross section of bread. Yeast mixed in dough utilizes sugar present in it and produces CO₂ through fermentation; exit of gas causes formation of pores and is responsible for sponginess of bread.

Needs of Biotechnology

The population of world increased dramatically. This will bring huge burden on biological resources (animal/plant) to provide food for all. Naturally occurring animal, plant or microbial strains have few limitations for them to be utilized for desired products due to following reasons-

1. Purity of the living stock.
2. Production of undesired products.
3. Secretion of toxic metabolic by-products.
4. Inability to withstand harsh biochemical processes/treatments.

BIOTECHNOLOGY
DR. NAZAR A. HAMZAH

- 5. Higher production cost.
- 6. Susceptible to disease and other environmental conditions.

The existing technology today enables us to engineer plants and animals making them suitable for maximum production. Living organism has a complex cellular structure, metabolic pathways, genetic make-up, and behavior in the synthetic growth media and understanding these processes can help us to modulate specific process/environmental condition or metabolic pathways to achieve the goal of biotechnology. Advancement in different fields of science has paved ways to solve several issues responsible for lower yield of products. Few of the selected science research areas contributing into the development of biotechnology are given in the Figure 1.2. The foundation of biotechnology relies on the research & development activities in different areas of science and interaction of interdisciplinary areas. The research in the field of plant biotechnology allowed us to produce plants through micro-propagation but with the evident advancement of genetic engineering, it is now possible to produce plant with predefined characteristics imprinted at genetic level through genetic engineering. The similar relationship may also exist for many other overlapping areas and as a result biotechnological operation output is amplified several folds.

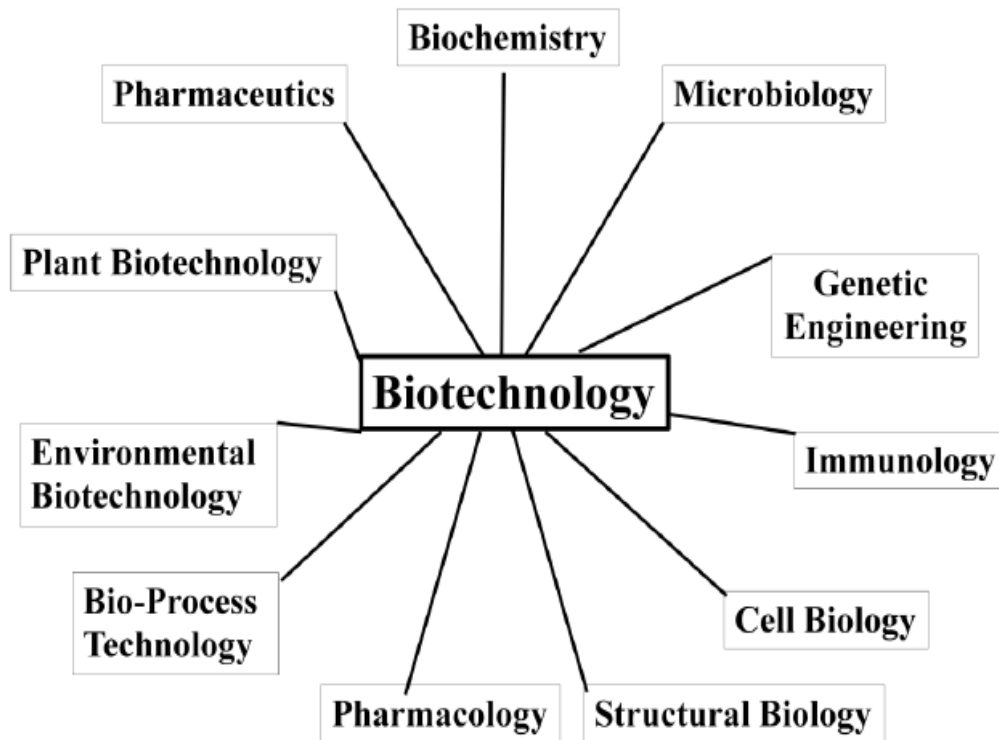


Figure 1.2: Different Science fields contributing into the advancement of biotechnology

Historical Advancement of Biotechnology

Biotechnology related activities depend on two parameters: technological advancement and knowledge of available biota. Technological up gradation goes parallel with the over-all understanding of physical and chemical phenomenon in different time periods. Hence, Biotechnology starts as early as human have realized the importance of organism (animal/plants or microbes) to improve their life-style. A systematic chronological description of biotechnological advancements over the course of different time periods is given in Table 1.1.

BIOTECHNOLOGY
DR. NAZAR A. HAMZAH

The earliest biotechnology related activities are selection and cross breeding of high yielding animals, cross breeding of plants to acquire specific phenotype and preserving the seeds of high yielding crop plant for next sowing season. These were few initial scientific experiments and based on the results, human have made significant modification in available biota. In last century, the systematic and scientific study of living objects with advanced technology has given immense potential to human imagination to either genetically manipulate living organism with desired phenotype or mimic metabolic reactions in an in-vitro system (either in test tube or in cells) to produce molecules with therapeutic importance. Such as “Humulin” is the insulin being produced in bacterial expression system and it is now been making life of millions of diabetic patients easier. Similarly during this era, drought, pest or abiotic resistant plants, high milk yielding animals, transgenic bacteria to produce biofuel, degrade environmental hazard or chelation of heavy metal have been developed. In addition, the historical advancement of biotechnology will not be complete without mentioning development of procedure for artificial insemination and test-tube baby for thousands of couples.

Table 1.1: Important milestones of Biotechnology

S.No.	Time Period	Major break-through
1.	7000 BC-100CE	<ul style="list-style-type: none"> • Discovery of fermentation • Crop rotation as a mechanism to improve soil fertility. • Animal and plant products as a source of fertilizer and insecticide respectively.
2.	Pre-20th Century	<ul style="list-style-type: none"> • Identification of living cell and bacteria • Discovery of small pox vaccine, rabies vaccine. • Process development to separate cream from milk, • Discovery of artificial sweeteners, “invertase”. • Discovery of DNA and chromosome responsible for genetic traits.
3	20th Century	<ul style="list-style-type: none"> • Discovery of Pencillin. • 3-D Structure of DNA. • Fabrication of artificial limb and arms, • Production of human insulin in bacteria “Humulin”. • Discovery of PCR. • Gene therapy, • Procedure for artificial insemination and test-tube baby. • Cloning of first mammal “Dolly”.
4	21st Century	<ul style="list-style-type: none"> • Vertebrate, invertebrate and bacterial genome sequences. • Completion of Human Genome sequence. • Sequencing of Rice genome. • Discovery of Nano radio. • Invention of Bionic leg.

BIOTECHNOLOGY
DR. NAZAR A. HAMZAH

Applications of Biotechnology

Biotechnology has influenced human life in many ways by inventions to make his life more comfortable. Many scientific fields contribute to biotechnology and in return it gives product for their advancement. Few of the biotechnology applications are given in Figure 1.3. The brief description of application of biotechnology in different field is as follows-

Plant sciences: Genetic Engineering has allowed us to produce genetically modified plants with diversified properties such as resistance against pest, drought and abiotic stress. It has enabled us to produce edible plants with short life-span or ability to grow in different season to increase the number of crops in a year to ultimately increase the food production. Horticulture has used biotechnology tools to produce plants with multiple colors, shades, aroma to increase the production of natural colors and scent. A detail description of other biotechnology application in plant sciences is discussed in next lectures.

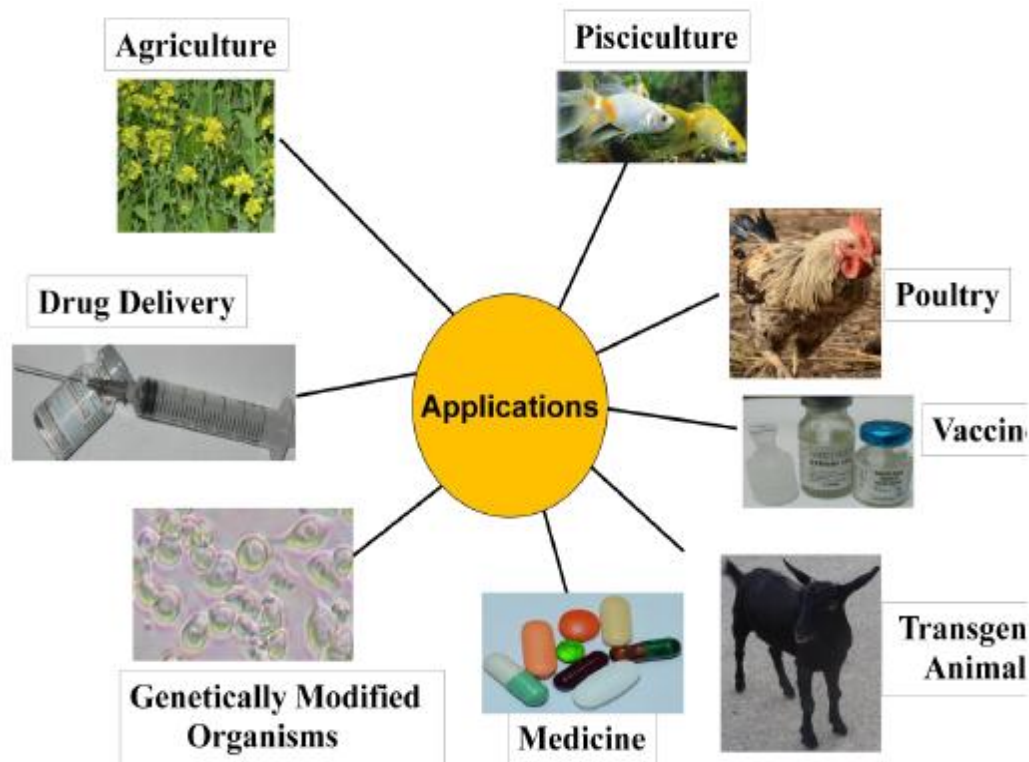


Figure 1.3: Impact of Biotechnology on different fields & human life.

Animal sciences: One of the early applications of biotechnology in animal science is developing method to separate cheese and other food products from milk by enzyme and microbes. Genetic engineering in conjugation with cell biology and biochemistry has developed multiple products of animal origin. Transgenic animal strains with desired phenotype such as high milk yielding animals, fishes and hens with more fat content. A detail description of other biotechnology application in animal sciences is discussed later.

Medicine and Medical Sciences: Biotechnology helped identification of drug like molecules, antibiotics and other medicines. At present a number of antibiotics are being produced by fermentation or in cell based systems. Apart from antibiotic, vaccine, diagnostic kits and other immunotherapy are gift of biotechnological

BIOTECHNOLOGY

DR. NAZAR A. HAMZAH

advancement. Development of artificial limb, arms, heart and medical procedures to perform open-heart operation, dialysis, artificial insemination, test-tube baby and other medical procedures.

In the current lecture I have put effort to briefly discuss about biotechnology, its scope and impact on human life with several customized products. The Development of technology and generation of product has multiple steps and understanding these steps are being covered in this course with a discussion of biotechnology application at the end. By the end of this course, student will be able to understand following aspects of biotechnology:

1. Basic metabolic pathways and their regulation.
2. Microbial growth kinetics with an emphasis on fermentation
3. Basic molecular biology tools used in biotechnology.
4. Basic methodology for product recovery and analysis.

Reference: NPTEL – Biotechnology – Fundamentals of Biotechnology by Vishal Trivedi. Joint initiative of IITs and IISc – Funded by MHRD