Introduction to Biotechnology

The root words of biotechnology are ancient Greek:

- Bios: "life"
- Technikos: “Skillfully made "tool"
- Logos: "Study of," "word," "essence"

Biotechnology- “**The study of living tools"-** is used in agriculture, food processing, industrial production, environmental cleanup and medicine.

A set of modern tools that utilize living organisms or parts of it cell or tissue or genes/DNA to make or modify or improve plants or animals or develop microorganisms for specific use or their large scale production.

"Utilization of organisms or its organells or biological process to make product or to solve problems for the welfare of mankind."

The Convention on Biological Diversity (CBD, 2000) biotechnology means "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use".

Biotechnology - production of goods and services using biological organisms, systems and process.

History of Biotechnology:

Biotechnology seems to be leading a sudden new biological revolution. Biotechnology is NOT new. Man has been manipulating living things to solve problems and improve his way of life for millennia. The term biotechnology was coined in 1919 by Karl Ereky, an Hungarian engineer. At that time, the term meant all the lines of work by which products are produced from raw materials with the aid of living organisms. Although now most often associated with the development of drugs, historically biotechnology has been principally associated with food such as malnutrition and famine. The history of biotechnology begins on brewing techniques for beer.

Early agriculture concentrated on producing food. Plants and animals were selectively bred and microorganisms were used to make food items such as beverages, cheese and bread. The ancient Egyptians made wine using fermentation techniques based on an understanding of the microbiological processes that occur in the absence of oxygen. Egyptians also applied fermentation technologies to make dough rise during bread making.

The late eighteenth century and the beginning of the nineteenth century saw the advent of vaccinations, crop rotation involving leguminous crops, and animal drawn machinery.

The end of the nineteenth century was a milestone of biology. Microorganisms were discovered, Mendel's work on genetics was accomplished, and institutes for investigating fermentation and other microbial processes were established by Koch, Pasteur, and Lister.

Biotechnology at the beginning of the twentieth century began to bring industry and agriculture together. In 1928, Alexander Fleming discovered the mold *Penicillium*. In 1940, penicillin became available for medicinal use to treat bacterial infections in humans. The biotechnical focus moved to pharmaceuticals. In 1953, James Watson and Francis Crick's were discovered the structure of DNA. The field of modern biotechnology is generally thought of as having been born in 1971 when Paul Berg's experiments in gene splicing had early success. Herbert W. Boyer and Stanley N. Cohen significantly advanced the new technology in 1972 by transferring genetic material into a bacterium, such that the imported material would be reproduced. In 1978, Boyer was able to take pieces of human DNA and isolate a gene for insulin using biotechnology. In the 1980s, testing of biotechnology-derived foods began, and after its FDA approval in 1994, the FlavrSavr® tomato gave consumers a more flavorful tomato that stays fresh longer. Today's biotechnology has its "roots" in chemistry, physics, and biology.

Traditional and New Biotechnology:

Although the term biotechnology is of recent origin, the discipline itself is very old. Man began employing microorganisms as early as 5000 BC for making wine, vinegar, bread etc. Some aspects of biotechnology are as ancient and familiar as adding yeast to bread dough; others are as recent and unfamiliar as genetic engineering.

Traditional: Biotechnology has been employed by humans for millennia. The ability of microorganisms to produce acids and gasses as a result of normal cell metabolism has been taken advantage of to make new and exciting foods for generations. Examples include production of beer, cheese and bread.

New Biotechnology: Recent developments in molecular biology have given Biotechnology a new meaning, new horizon and new potential through use of recombinant DNA technology. New biotechnology to modify the genetic material of living cells to produce new substances or perform new functions. Gene technology or genetic engineering allows the biologist to take a gene from one cell and insert it into another cell which may be plant, animal or microbial (bacterial or fungal), or to produce new combinations of genes.

Basic Techniques of Biotechnology:

The two basic techniques used in biotechnology are

1. Tissue culture(Soft Biotechnology)
2. Genetic engineering (Hard Biotechnology)

Scope & Importance of Biotechnology:

Biotechnology has rapidly emerged as an area of activity having a marked realized as well as potential impact on virtually all domains of human welfare, ranging from food processing, protecting the environment, to human health. As a result, it now plays a very important role in employment, production and productivity, trade, economics and economy, human health and the quality of human life throughout the world. This is clearly reflected in the creating of numerous biotechnology companies throughout the world, and the movement of noted scientists, including Nobel laureates, to some of these companies. The total volume of trade in biotechnology products in increasing sharply every year, and it would soon become the major contributor to the world trade. Many commentators are confident that the 2lst century will be the century of biotechnology, just as the 20th century was the era of electronics.

These are but some of the examples where biotechnology has made notable contribution.

Table1. Some selected contributions of biotechnology to human welfare.

Products	**Remarks**
Medical Biotechnology: Monoclonal antibodies (used for disease diagnosis, e.g., venereal diseases, hepatitis B and other viral diseases, cancer, etc.)	Produced by hybridoma technology.
DNA probes (used for disease diagnosis, e.g. kalazar, sleeping sickness, malaria etc.)	Produced by genetically engineered bacteria.
Synthetic vaccines (cleaner, safer; e.g. human hepatitis B virus, E. coli vaccines for pigs, rabies virus etc.)	Produced by genetically engineered bacteria.
Valuable drugs like human insulin, human interferon, human and bovine growth hormone etc.	Produced by genetically engineered bacteria
Gene therapy to cure genetic diseases, e.g., Hunting- ton`s chorea, Thalasemia, cystic fibrosis.	Techniques still in the developing stages.
Babies of specified sex (artificial insemination with X-or Y-carrying sperms prepared by sperm separation techniques).	lt is feared that this may unfavorably change the sex ratio in the population.
Identification of parents/criminals using DNA finger-printing.	Very accurate and reliable; from even blood or semen stains, hair roots etc.
Industrial Biotechnology: Production of useful compounds, e.g., ethanol, lactic acid, glycerin, citric acid, gluconic acid, acetone etc.	Produced by microorganisms, mainly bacteria, from less useful substrates.
Production of antibiotics, e.g., Penicillin, Streptomyein, Erythromyein, Mitomycin, Cycloheximide etc.	Produced by fungi, bacteria and actinomycetes as secondary metabolites.
Transformation of less useful and cheaper compounds into more useful and valuable ones, e.g., steroid hormones from sterols, sorbose from sorbitol etc.	Generally, by microorganisms or immobilized enzymes in aerobic fermenters.
Production of enzymes, e.g. α-amylase, proteases, lipases etc.	From fungi, bacteria etc for use in detergent, textile, leather, dairy etc. industries, and in medicines.
Single cell proteins (SCP) from bacteria, yeast, fungi or algae for human feed and animals feed (as supplements).	In fact, SCP is the total microbial biomass freed from toxins and contaminatants, if any.
Fuel (mainly ethanol, sometimes biogas) production from cheap, less useful and abundant substrates, e.g., sugarcane bagasse, wood etc.(biofuel & bioenergy)	Produced through fermentation by microorganisms. Cowdung-based biogas being popularized in India/Bangladesh.
Mineral extraction through leaching from low grade ores, e.g., copper, uranium etc.(bioleaching/microbial mining)	Due to action of microbes, mainly bacteria.
Immobilization of enzymes for their repeated industrial application.	More attractive than the use of whole microorganisms.
Protein/enzyme engineering to change the primary structure of existing proteins/enzymes to make them more efficient,	Extensive use of computers for generating models of protein molecules. It is hoped to

change their substrate specificity, e.g., successes with T4 lysozyme, trypsin, subtilisin, lactate dehydrogenase etc.	change RUBIS-CO so as to minimize its affinity for $O_{2.}$
Production of immunotoxins by joining a natural toxin with a specific antibody.	These destroy specific cell types; may provide a potent treatment for cancer.
Animal biotechnology: Test tube babies in humans; involves in vitro fertilization and embryo transfer.	Couples suffering from infertility can have babies.
Hormone-induced superovulation and / or embryo splitting in farm animals; involves embryo transfer and, in many cases, in vitro fertilization.	For rapid multiplication of animals of superior genotype.
Production of transgenic animals for increased milk, growth rate, resistance to diseases etc. and production of some valuable proteins in milk/urine/blood.	Transgenic mice, pigs, chicken, rabbits, cattle, sheep produced.
Environmental Biotechnology: Efficient sewage treatment, deodorization of human excreta. The use of organisms, usually microorganisms, to break down pollutants in soil, air or groundwater.	Efficient strains of micro-organisms developed.
Degradation of petroleum and management of oil spills. Detoxification of wastes and industrial effluents. Biocontrol of plant diseases and insect pests by using viruses, bacteria, amoebae, fungi etc.	A strain of *Psedomonas putida*. Genetically engineered microbes. Environment friendly; avoids the use of pesticides etc., which cause pollution.
Plant Biotechnology: Embryo culture to rescue otherwise inviable hybrids, to recover haploid plants from interspecific hybrids, micropropagation of orchids etc.	The first two applications are the most remarkable.
Rapid clonal multiplication through meristerm culture, e.g., of many fruit and forest trees, such as, teak.	Very high rates of multiplication; conventional rates very low, e. g., in mango.
Recovery of virus and other pathogen-free stocks of clonal crops; meristerm culture is generally combined with thermotherapy.	Very useful in clonal crops; particularly for germplasm exchange.
Germplasm conservation through storage in liquid nitrogen at-l96^{0}C (cryopreservation) or through slow growth.	Particularly useful in clonal crops, especially in those producing tubers, storage roots etc.
Rapid isolation of homozygous lines by chromosome doubling of haploids produced through anther culture/interspecific hybridization.	Very successful in variety development in China, e.g., in rice and wheat.
Molecular markers, e.g. RFLPs and RAPDs for linkage mapping and mapping of quantitative trait loci.	A powerful tool for indirect selection for quantitative traits; several other important applications.
Isolation of stable somaclonal variants with improved yield/yield traits/disease resistance/resistance to cold, herbicides, metal toxicity, salt and other abiotic stresses.	Many examples of successful isolation; many variations are stable and heritable; often due to gene mutations, which may, sometimes, be novel.
Gene transfers (genetic engineering) for insect resistance, protection against viruses, herbicide resistance, storage protein	Mainly using the Ti plasmid of *Agrobacterium*; also through particle gun,

improvement etc.	free DNA uptake, electroporation etc.; A revolutionary development in crop improvement.

Branches of Biotechnology:

Red Biotech: is applied to medical processes. Some examples are the designing of organisms to produce antibiotics, and the engineering of genetic cures through genomic manipulation.

White/Grey Biotech: applied to industrial processes. An example is the designing of an organism to produce a useful chemical.

Green Biotech: applied to agricultural processes. An example is the designing of transgenic plants to grow under specific environmental conditions or in the presence (or absence) of certain agricultural chemicals.

Blue Biotech: used to describe the marine and aquatic applications of biotechnology, but its use is relatively rare.

Biotechnology research Disciplines:

- Biochemistry
- Cell Biology
- Molecular Biology
- Microbiology
- Genetics
- Immunology
- Engineering
- Materials Science
- Computer Science
- Mathematics

Present Status of Biotechnology in Bangladesh:

- Plant Biotechnology

l. Soft Core Biotechnology

- Tissue Culture
- Bio-fertilizer
- Vermiculture etc.

2. Hard Core Biotechnology

• Genetic Engineering

• Recombinant DNA technology

Plant Biotechnology

- Micro-propagation of ornamental, medicinal, timber, flower and fruit plants. e.g. banana, orchids, strawberry, pointed gourd, gladiolus etc.
- Production of doubled haploid plants in banana through anther culture.
- *In vitro* micro-tuber production in potato.
- Transgenic sugarcane with stem borers and red rot resistance genes.
- Improvement of wheat using breeding and in vitro techniques.
- *Agrobacterium*-mediated genetic transformation systems in tobacco, potato and papaya have been established.
- *Agrobacterium* mediated transformation in lentil and peanut for fungus resistance.
- Genetic transformation in rice and maize with PRP gene(s)
- Genetic improvement of Jute for abiotic stresses.
- Development of a genetic map and stem rot resistance of jute.
- Transformation of rice for Salinity tolerance.
- DNA marker to help breeding for salt tolerance in rice.
- Development of nine Bt brinjal varieties and two LBR potato varieties.
- Development of arsenic resistance in crop plants through genetic engineering to combat food chain contamination in Bangladesh.

Microbial Biotechnology

- Mass scale production Of *Spirulina* (BCSlR)
- Production of bio-fertilizer.

Bioenergy:

- BCSIR is leading the project
- 30,000 biogas plant installed by 2010
- 100,000 more is the process of installation

National Committee on Biotechnology (NCB) product Development:

"ln September l993, a national committee on Biotechnology product development was formed and finally the following products were selected."

- *Rhizobial* inoculation for use as bio-fertilizer
- Yeasts as protein supplement of poultry feed.
- Tissue culture based foot and mouth disease vaccine.
- Bamboo sapling by *ex-vitro* and *in-vitro* methods.
- Biogass technology for fuel, fertilizer and environmental pollution control.
- Production of high quality potato seeds using tissue culture.