BIOTECHNO ACTIVITY BOOK

Compiled by :

EduHeal Foundation
New Delhi

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Preface

Biotechno Activities book is a small step torwards encouraging school students to take up biotechnology. We at EduHeal Foundation still need lot of help and encouragement from school teachers and Principal in accomplishment of our goal. It is you who form the vital link between EduHeal Foundation and students as you can further encourage students to know about biotechnology on a day to day basics. We would also not sit idle but make efforts to increase interest :

- By publishing books like Biotechno Activities Books.
- Create awareness by conducting Nationwide Biotechnology Olympiad.
- Teacher Tranining Programme in basics of genetics and Biotechnology.
- Career Development Workshop for Students.
- Virtual Genetic Lab.
- Networking to enhance school/Govt./ Industry Interface.

EDUHEAL FOUNDATION wishes to thank the following for their support

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With best wishes

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CLASS - XII

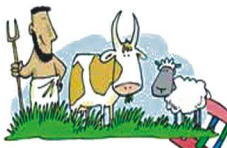
BIOTECHNOLOGY AN INTRODUCTION

A wide definition of biotechnology is “any technique that uses living organisms, or substances from those organisms, to make or modify a product, to improve plants or animals, or to develop microorganisms for specific uses”.With this broad definition, one readily sees that biotechnology is not a modern practice, but has been practised for centuries. In the area of agriculture, farmers have been crossing plants to produce hybrids and varieties that are improvements over existing ones. Indeed, the Austrian monk Gregor Mendel, who started the field of genetics over a hundred years ago, did that by crossing pea plants. Enthusiastic gardeners have, over the years, generated over four hundred varieties of the rose plant - using the methods or grafting and selecting. Veterinarians and livestock breeders have done similarly with animals. In the field of health, Edward Jenner of Britain realised as early as 1820 that prior infection protected one against the recurrence of smallpox; using this, he vaccinated a dairymaid with previously killed pox virus and provided her with defence against the dreaded disease. The great French scientist Louis Pasteur, who died one hundred years ago, showed how invisible germs spoil milk, wine and cheese, and how the simple act of boiling inactivates them - and in this way developed the important technique which goes by his name - pasteurisation. He also rescued the wine industry of France from disastrous losses by the introduction of proper strains of yeast, proper conditions of aeration, temperatures and storage and other methods in what today is known as downstream processing.

Biotechnology has been intuitively and empirically used in the kitchen for quite some time. Marination, caramelisation, food preservation using naturally occurring substances, pickling, fermentation, tenderising meat using papaya extracts, flavour enhancement using chemicals, gelatinisation, use of skins, bladders and colloidon membranes for selective separation - these are some examples of the practice of food biotechnology.

Medicine came of age only in the twentieth century. Yet, it owes its present-day sophistication to centuries of a whole host of experiments - many of which were crude, tentative and even bizarre, but several of which were curiously successful; later research provided the molecular and technological rationale behind some of these success stories. Some instances are the use of saliva to control bleeding and prevent further infection; liver extracts as health builders for convalescents, the herbal products of India, SouthEast Asia,

Biotechnology Through The Ages



8000 BC
HUMANS BEGIN TO GROW AND KEEP LIVESTOCK. THE PLANTS AND ANIMALS BEGIN TO IMPROVE AS THE FARMERS SELECT THE BEST OFFSPRING TO GROW THE NEXT GENERATION.

4000 - 2000BC
YEAST IS USED IN EGYPT TO CAUSE BREAD TO RISE. CHEESE AND WINE ARE MADE IN SUMERIA, CHINA AND EGYPT.

1796
EDWARD JENNER GIVES DOSES OF COWPOX TO A CHILD. THIS PREPARES THE CHILD'S IMMUNE SYSTEM TO FIGHT A SIMILAR VIRUS IN HUMANS (CALLED SMALLPOX), A TREATMENT NOW KNOWN AS A "VACCINE".

1859
CHARLES DARWIN PUBLISHES HIS THEORY OF EVOLUTION THROUGH "NATURAL SELECTION". WITHIN 20 YEARS IT HAS INFLUENCED BREEDERS, WITH MAJOR IMPACT ON PLANT AND ANIMAL BREEDS.

1865
GREGOR MENDEL, A MONK, DETERMINES THE RULES OF INHERITENCE. HE ASSERTS THAT FEATURES ARE PASSED FROM PARENTS TO THEIR OFFSPRING THROUGH DISCRETE UNITS, LATER CALLED GENES.

1928
SIR ALEXANDER FLEMING DICOVERS THAT THE MOULD CONTAMINATING ONE OF HIS EXPERIMENTS KILLS CERTAIN BACTERIA. PENICILLIN IS LATER ISOLATED FROM THE MOULD, LEADING TO THE DEVELOPMENT OF ANTIBIOTICS.

1953
JAMES WATSON AND FRANCIS CRICK DESCRIBE THE STRUCTURE OF DNA (DEOXYRIBONUCLEIC ACID) AS A DOUBLE HELIX COMPOSED OF JUST FOUR DISTINCT NUCLEOTIDE UNITS.

1966
THE "GENETIC CODE" IS WORKED OUT. A SEQUENCE OF THREE NUCLEOTIDE BASES DETERMINES EACH OF 20 COMMON AMINO ACIDS (THE BUILDING BLOCKS OF PROTEIN).

1972
THE DNA COMPOSITION OF HUMANS IS FOUND TO BE 99% SIMILAR TO THAT OF CHIMPANZEES AND GORILLAS.

1973
STANLEY COHEN AND HERBERT BOYER TRANSFER DNA FROM ONE ORGANISM TO ANOTHER. THIS IS THE FIRST SUCCESSFUL TRANSFER OF GENES BETWEEN DIFFERENT INDIVIDUALS.

1974
FREDERICK SANGER DEVELOPS A METHOD FOR DETERMINING THE ORDER OF NUCLEOTIDES IN A DNA STRAND. THIS IS CALLED SEQUENCING.

1990
- THE FIRST GOVERNMENT-APPROVED GENE THERAPY IN A HUMAN IS PERFORMED IN THE UNITED STATES, ON A FOUR-YEAR OLD GIRL SUFFERING FROM AN IMMUNE DISORDER.

- AN INTERNATIONAL COLLABORATIVE EFFORT TO MAP ALL THE GENES IN THE HUMAN GENOME IS LAUNCHED UNDER THE SPONSORSHIP OF THE HUMAN GENOME PROJECT.

1982
- A SYNDROME IS DISCOVERED WHICH SEVERELY IMPAIRS THE IMMUNE SYSTEM. IT IS GIVEN THE NAME *AIDS*, *AQUIRED IMMUNE DEFICIENCY SYNDROME*. IT IS CAUSED BY THE *HUMAN IMMUNODEFIENCY VIRUS, HIV*.

- BACTERIA ARE GENETICALLY ENGINEERED TO PRODUCE A HUMAN FORM OF INSULIN FOR THE TREATMENT OF DIABETES. UNTIL THIS POINT, DIABETES SUFFERERS USED INSULIN FROM PIGS.

1984
GENETIC FINGERPRINTING IS DEVELOPED. IT IS USED TO LINK A SUSPECT TO GENETIC MATERIAL FOUND AT A CRIME SCENE.

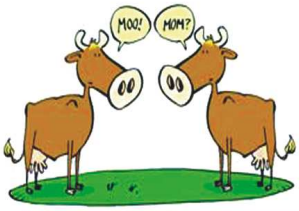
1994
THE FIRST GENETICALLY MODIFIED (GM) CROP IS APPROVED FOR COMMERCIAL PRODUCTION IN THE UNITED STATES. IT IS THE FLAVR SAVR TOMATO AND IT IS ENGINEERED TO SLOW THE RIPENING PROCESS THUS IMPROVING SHELF LIFE.

1997
SCOTTISH SCIENTISTS ANNOUNCE THE BIRTH OF A SHEEP NAMED DOLLY. SHE IS THE FIRST HIGHER MAMMAL TO BE CLONED FROM AN ADULT CELL. THIS CLONING WAS SUCCESSFUL AFTER 276 ATTEMPTS.

1997
First insect resistant BT cotton is grown commercially

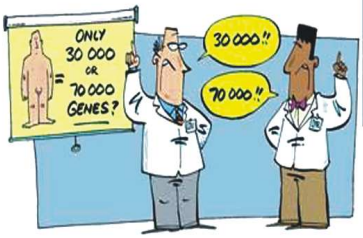
1998
40 million hectare of crops are planted globally (predominatly corn)

2000
GOLDEN RICE IS GENETICALLY ENGINEERED TO CONTAIN HIGH LEVELS OF VITAMIN A TO HELP PREVENT BLINDNESS.



2003
CHAMPION COW A SOUTH AFRICAN DAIRY COW IS THE FIRST HIGHER MAMMAL TO BE CLONED ON THE AFRICAN CONTINENT.

2006
Dolly, the first cloned sheep died due to arthiritis.



2002
THE HUMAN GENOME PROJECT IS COMPLETED, REVEALING APPROXIMATELY 30 000 INDIVIDUAL GENES. SCIENTISTS GO ON TO DISPUTE THIS FINDING CLAIMING THAT THE NUMBER OF HUMAN GENES IS CLOSER TO 70 000.

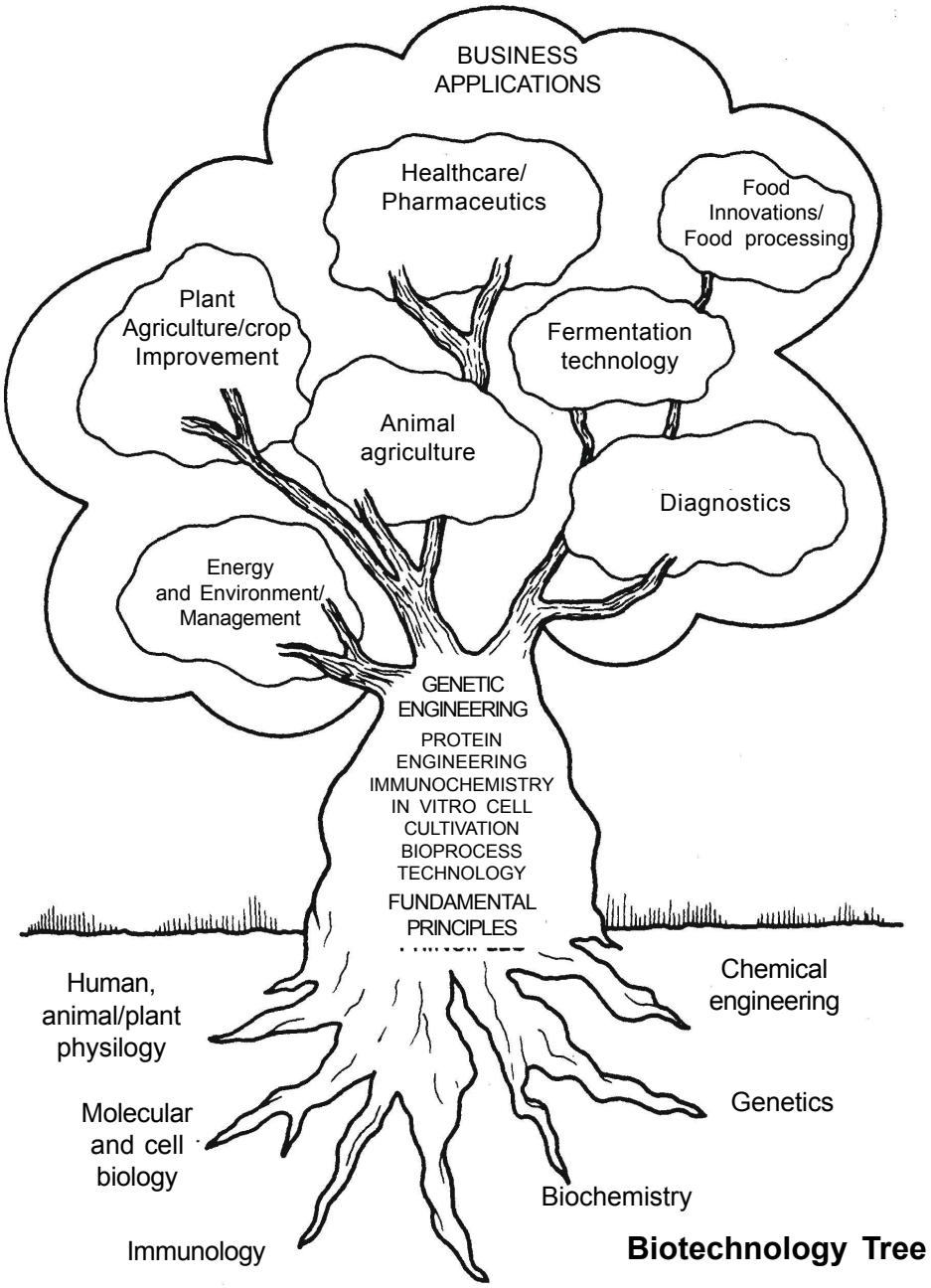
China and Korea as antidepressants, anti-hypertensives, and speciality medicines.

The most important advance from the biotechnological point of view came from those in the molecular genetics of microbes about 20 years ago. It became possible to isolate plasmids which are autonomous, non-chromosomal, cyclic DNA molecules found in the cytoplasm of microbial cells. It further became possible to selectively cut and open the circular DNA that constitutes the plasmid through the use of specific enzymes called restriction endonucleases. Soon it also became possible to introduce DNA sequences into linearised (cut) plasmid DNA and reseal (ligate) the circle. This “cut and paste” method has allowed the introduction of foreign DNA into the plasmids. The discovery of restriction enzymes for cuttinig DNA at specific spots and ligases that covalently join DNA molecules through phosphodiester bonds were revolutionary steps in molecular engineering.

Practising Biotechnology at various levels

System	Examples	Utilisation
At the level of small molecules	Steroids, lipids, sugars, vitamins, coenzymes	Drugs, packaging or encapsulating materials, nutrition, food, cleaning and detergency.
Macromolecular level	Proteins, nucleic acids, polysaccharides	Catalysis, energy sources, copying and reproduction.
Organelle level	Membranes, cell extracts, chloroplasts, mitochondria	Separation, energy transduction, *in vitro* biochemistry
Cells with wall removed	Protoplasts	Hybrid cells and cell fusion
Cells	All types of microbial, plant and animal cells	Biochemicals, genetic engineering, various purposes of biotechnology.
Tissues	From plants and animals for use in medicine and surgery	Biochemicals
Organs and organisms	Plants, fruitflies, nematodes, frogs, mice, rats and rabbits	Chemicals, biochemicals, toxins, immunochemicals, drug testing transgenics.

Bio-Technology is a research oriented science, a combination of Biology and Technology. It covers a wide variety of subjects like Genetics, Biochemistry, Microbiology, Immunology, Virology, Chemistry and Engineering and is also concerned with many other subjects like Health and Medicine, Agriculture and Animal Husbandry, Cropping system and Crop Management, Ecology, Cell Biology, Soil science and Soil Conservation, Bio-statistics, Plant Physiology, Seed Technology etc.



Biotechnology Tree

Applications of Modern Biotechnology include :

- **Insect, fungal and virus tolerance** – by planting pest resistant crops less chemicals (pesticides) are used, lowering production costs and reducing the impact on the environment. Examples include potato, maize, cotton and tomato;
- **Stress tolerance** – increasing the tolerance of crops to extreme stresses such as drought, salt and frost could enable resource poor farmers to produce food in areas where it is most needed.
- **Herbicide tolerance** – when such crops are planted, more environmentally friendly broad-spectrum herbicides can be used. Examples include rice, cotton and beet;
- **Enhanced food value and nutrition** – such as changing oil pro-files in oilseed crops, and developing vitamin enriched staple crops such as rice, wheat and corn. Research is also focusing on reducing allergens, and enriching crops with protein.
- **Higher yields and greater crop stability** – this increases crop production per unit of land; • Control and minimise post harvest losses – this reduces the substantial losses after harvesting, and improves the shelf life of fruits and vegetables, such as tomato, contributing to a higher overall crop yield;
- **Reduce the loss of top soil and biodiversity** – by promoting low tillage production especially in marginal areas that are not ideal for agriculture;
- **Development of improved livestock vaccines** – for major diseases affecting productivity, diagnostic tools for disease detection and pedigree verification;
- **Impact on small-scale farmers** – with potentially large yield impacts and significant financial returns despite higher initial seed costs.

What Are The Benefits of Biotechnology ?

Modern biotechnology can make an important contribution to the national priorities of a country in a number of areas:

♦ **Enhanced Food security**

The promise of biotechnology in food production is its capacity to improve the quality and quantity of plants and animals quickly and effectively.

♦ **Improved Health care**

In addition to improved health through enhancing the nutritional quality of foods, there are many other uses of modern biotechnology that can further enhance human health:

- *Inexpensive medicine production* – Modern biotechnology is enabling the production of higher quality drugs at a lower cost;
- "*Biopharming*" – Crops are now being tested as possible delivery systems for pharmaceuticals, such as banana which could one day contain various vaccines;
- *Human Genome Project* – this research could one day enable genetic diseases to be understood, diagnosed and perhaps cured;
- *Gene Therapy* – medicines are being developed to target specific cells in the human body;

- *HIV/AIDS* – The production of vaccines for clinical trials is underway and if successful, the companies undertaking the research could produce the vaccine in large amounts at low cost so they are affordable;
- *Forensics and Diagnostics* – also known as genetic finger-printing, these techniques could provide invaluable evidence in bringing criminals to justice.

Environmental sustainability

In addition to reducing the amount of toxic chemical pesticides that are released into the environment though built in resistance to pests, herbicide resistance means that more environmentally friendly broad-spectrum herbicides can be used to eliminate competing weeds. More novel contributions GM can make towards sustainable development include:

- *Waste management: "Biomaterials"* – biodegradable plastics are being developed using a micro-organism that degrades polyethylene plastics;
- *Bioremediation* – the use of microorganisms such as bacteria to remove environmental and often poisonous pollutants from soil and water. Waste cleaning organisms, mainly plants, could be grown at treatment plants and contam-inated areas.

Industrial Development Processes

Current GM research is opening up future possibilities which could significantly contribute to national economies, and promote new global collaborations, such as:

- *Engineering traditional food crops to become valuable industrial crops* – e.g. canola is being used to produce high value industrial oil;
- *Improved/additional characteristics for processing* – such as potatoes that absorb less oil, and fruits with a longer shelf life, such as tomato;
- *Transforming raw materials* – useful enzymes are now mass produced at low cost and high quality for various industries;
- *Biomining* – this is the inexpensive extraction of precious metals from low-grade ores using microbes. Plants are also being developed to mine precious metals, for example Brassica, which concentrate gold from the soil in their leaves.