Concepts of Biotechnology

The term **"**Biotechnology" was first coined in 1919 by **Karl Ereky** which means products are produced from raw materials with the aid of living organisms.

Biotechnology is NOT new. Man has been manipulating living things to solve problems and improve his way of life for millennia. 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 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. During World War I, fermentation processes were developed that produced acetone from starch and paint solvents for the rapidly growing automobile industry. Work in the 1930s was geared towards using surplus agricultural products to supply industry instead of imports or petrochemicals. The advent of World War II brought the manufacture of penicillin. The biotechnical focus moved to pharmaceuticals. The "cold war" years were dominated by work with microorganisms in preparation for biological warfare as well as antibiotics and fermentation processes (Goodman, 1987).

Biotechnology is currently being used in many areas including agriculture, bioremediation, food processing and energy production. DNA fingerprinting is becoming a common practice in forensics. Production of insulin and other medicines is accomplished through cloning of vectors that now carry the chosen gene. Immunoassays are used not only in medicine for drug level and pregnancy testing, but also by farmers to aid in detection of unsafe levels of pesticides, herbicides and toxins on crops and in animal products. These assays also provide rapid field tests for industrial chemicals in ground water, sediment and soil. In agriculture, genetic engineering is being used to produce plants that are resistant to insects, weeds and plant diseases.

Definition

Biotechnology- Bio means life and technology means the application of knowledge for practical use *ie*., the use of living organisms to make or improve a product.

Other definitions for the term Biotechnology

- The use of living organisms to solve problems or make useful products.
- The use of cells and biological molecules to solve problems or make useful products. Biological molecules include DNA, RNA and proteins.
- The commercial application of living organisms or their products, which involves the deliberate manipulation of their DNA molecules.
- Make a living cell to perform a specific task in a predictable and controllable way.

Biotechnology has been described as "Janus-faced". This implies that there are two sides. On one side techniques allow DNA to be manipulated to move genes from one organism to another. On the other, it involves relatively new technologies whose consequences are untested and should be met with caution.

Stages of biotechnology development

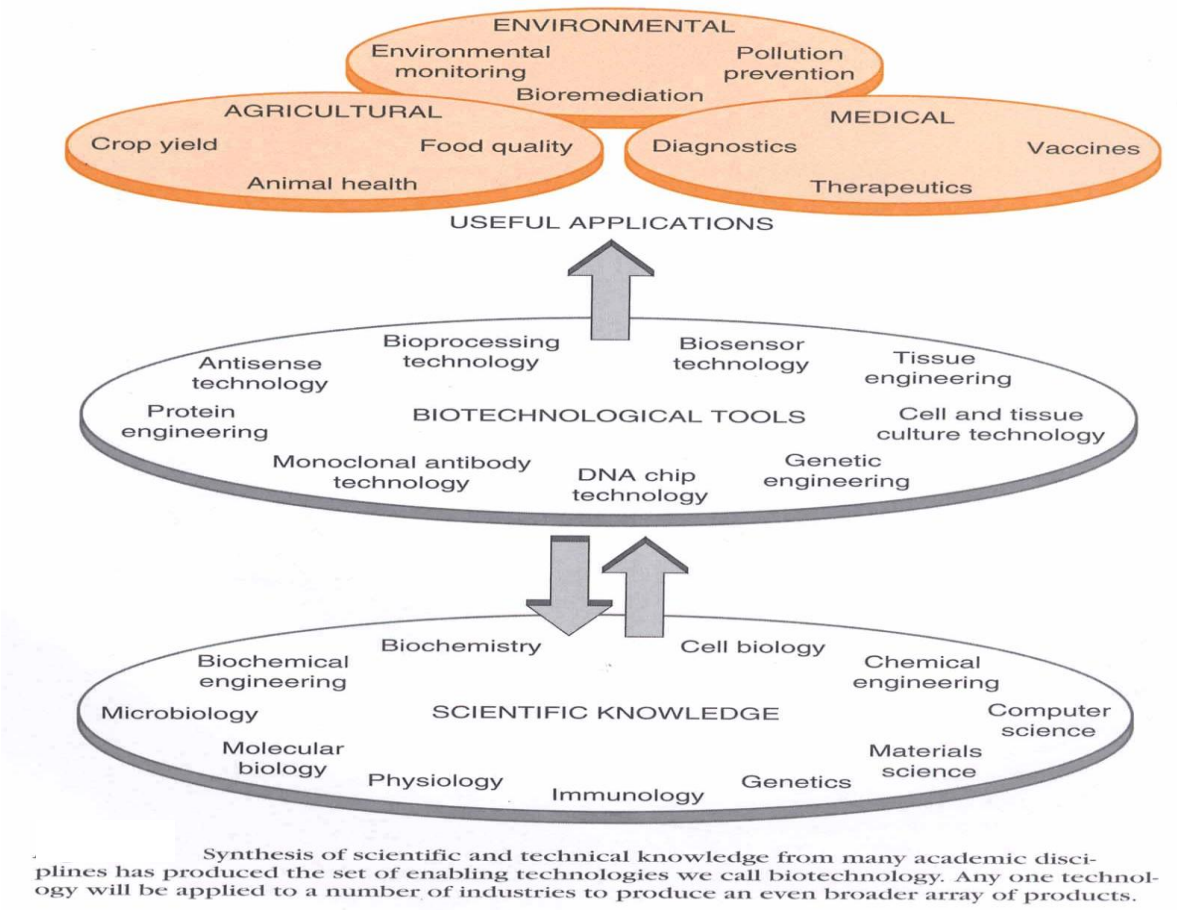
- ✓ Ancient biotechnology - 8000-4000 B.C

  Early history as related to food and shelter; includes domestication
- ✓ Classical biotechnology - 2000 B.C.; 1800-1900 AD

  Built on ancient biotechnology; fermentation promoted food production and medicine
- ✓ 1900-1953: Genetics
- ✓ 1953 - 1976: DNA research, science explodes
- ✓ Modern biotechnology - 1977

  Manipulates genetic information in organism; Genetic engineering

Biotechnology is a collection of various technologies that enable us to improve crop yield and food quality in agriculture and to produce a broader array of products in industries.



Synthesis of scientific and technical knowledge from many academic disciplines has produced the set of enabling technologies we call biotechnology. Any one technology will be applied to a number of industries to produce an even broader array of products.

Various technologies and their uses

- Genetic Engineering (Recombinant DNA) Technology

  The use of cellular enzymes to manipulate DNA

  Transferring DNA between unrelated organisms
- Protein Engineering Technology

  Improve existing/create novel proteins to make useful products
- Antisense or RNAi Technology

  Block or decrease the production of certain proteins
- Cell and Tissue Culture Technology

  Grow cells/tissues under laboratory conditions to produce an entire organism, or to produce new products
- Bioinformatics Technology

  Computational analysis of biological data, e.g., sequence analysis macromolecular structures, high-throughput profiling data analysis
- Functional Genomics (the -omics)

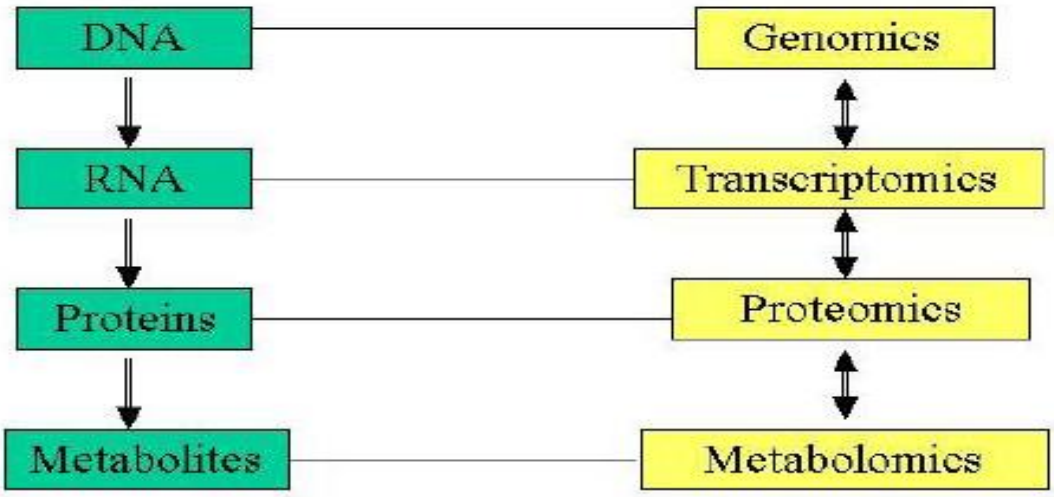
The use of genome-wide, high-throughput approaches to determine the biological function of all of the genes and their products

High-throughput technologies (the -omics)

- Transcriptomics (e.g. microarray expression profiling)
- Proteomics (e.g. structures/modifications/interactions of proteins)

  Proteins are responsible for an endless number of tasks within the cell. The complete set of proteins in a cell can be referred to as its *proteome* and the study of protein structure and function and what every protein in the cell is doing is known as *proteomics*. The proteome is highly dynamic and it changes from time to time in response to different environmental stimuli. The goal of *proteomics* is to understand how the structure and function of proteins allow them to do what they do, what they interact with and how they contribute to life processes.
- Metabolomics (e.g. metabolite profiling, chemical fingerprinting, flux analysis)

  Metabolomics is one of the newest 'omics' sciences. The *metabolome* refers to the complete set of low molecular weight compounds in a sample. These compounds are the substrates and by products of enzymatic reactions and have a direct effect on the phenotype of the cell. Thus, metabolomics aims at determining a sample's profile of these compounds at a specified time under specific environmental conditions
- Transgenomics (e.g. knock-out, knock-in, gene tagging, mutagenesis)
- Translational genomics



Applications of biotechnology & genomics

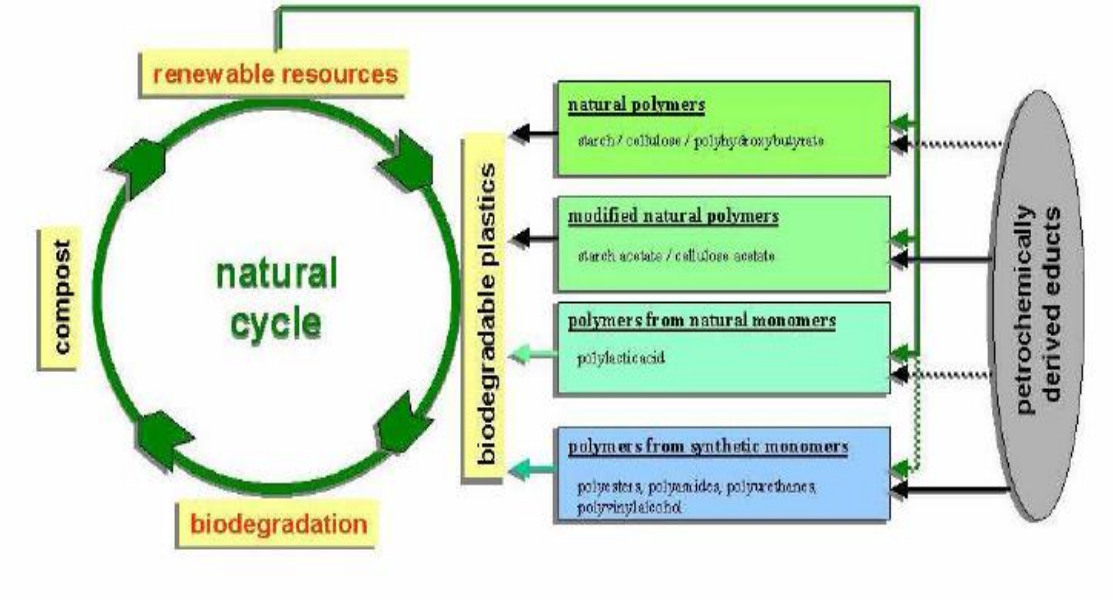
1. Environmental biotechnology

A. Environmental monitoring

• Diagnosis of environmental problems via biotechnology

B. Waste management

• Bioremediation: the use of microbes to break down organic molecules or environmental pollutants.



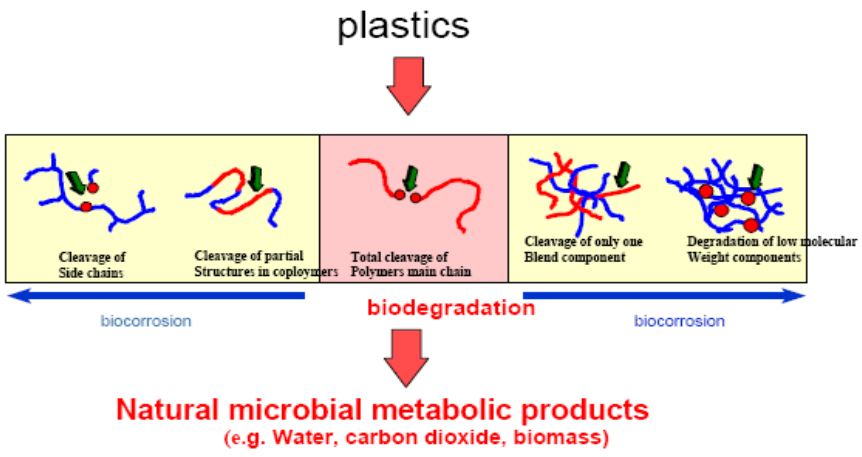
• Phyto remediation: the use of plants to remove pollutants (e.g. heavy metals) from the environment.

C. Pollution prevention

• Renewable resources

• Biodegradable products

• Alternative energy sources



2. Medical biotechnology

A. Diagnostics

B. Therapeutics

C. Vaccines

D. Medical research tools

E. Human Genome Research

3. Agricultural biotechnology

A. Animal Biotechnology

B. Crop Biotechnology

C. Horticultural Biotechnology

D. Tree Biotechnology

E. Food processing

4. Evolutionary and ecological genomics

Finding genes associated with ecological traits and evolutionary diversification.

Common goals: health, productivity

Plant biotechnology /Agricultural biotechnology

A process to produce a genetically modified plant by removing genetic information from an organism, manipulating it in the laboratory and then transferring it into a plant to change certain of its characteristics . In Nutshell it's the manipulation of plants for the benefit of mankind

The plants are mainly manipulated for two major objectives

A. Crop improvement

- Herbicide tolerance (in use)
- Pest resistance (in use)
- Drought tolerance
- Nitrogen fixing ability
- Acidity and Salinity tolerance

B. Nutritional value of crops

- Improving food quality and safety
- Healthier cooking oils by decreasing the conc. of saturated fatty acids in vegetable oils
- Functional foods: foods containing significant levels of biologically active components that impart health benefits

Various technologies applied in plant biotechnology includes

- Genetic engineering/ recombinant DNA technology
- Tissue culture
- Molecular breeding – MAS

Traditional plant breeding involves cross-breeding of similar plants to produce new varieties with different traits. But it takes many generations to achieve desired result. By using various biotechnological tools, crop improvement can be achieved faster and it even facilitates to transfer genes from unrelated species

Genetic engineering

Manipulation of genes is called genetic engineering or recombinant DNA technology. It removes gene(s) from one organism and either

- Transfers them to another
- Puts them back in the original with a different combination

Various gene transfer techniques used in genetic engineering includes

- Agrobacterium mediated gene transfer: Desired trait is isolated from DNA of original organism, inserted into *Agrobacterium*, target plant is infected. Cells that accept the DNA are grown into plants with the new trait.
- Gene gun: DNA that codes for the desired trait is coated onto tiny particles of tungsten and fired into a group of plant cells. Cells that accept the DNA are grown into plants with the desired trait.

Tissue culture

Tissue culture manipulates cells, anthers, pollen grains, or other tissues; so they live for extended periods under laboratory conditions or become whole, living, growing organisms; genetically engineered cells may be converted into genetically engineered organisms through tissue culture.

Marker Assisted Selection

Marker-aided genetic analysis studies DNA sequences to identify genes, QTLs (quantitative trait loci), and other molecular markers and to associate them with organism functions, i.e., gene identification. Marker-aided selection is the identification and inheritance tracing of previously identified DNA fragments through a series of generations.

Applications of biotechnology in agriculture (plants)

A. **Crop Improvement**
   - Plants with built in resistance to pest and Diseases.
   - Plants with built in tolerance to environmental conditions
   - Improved color and quality

B. **Pharmaceuticals**
   - Plants that produce edible vaccines

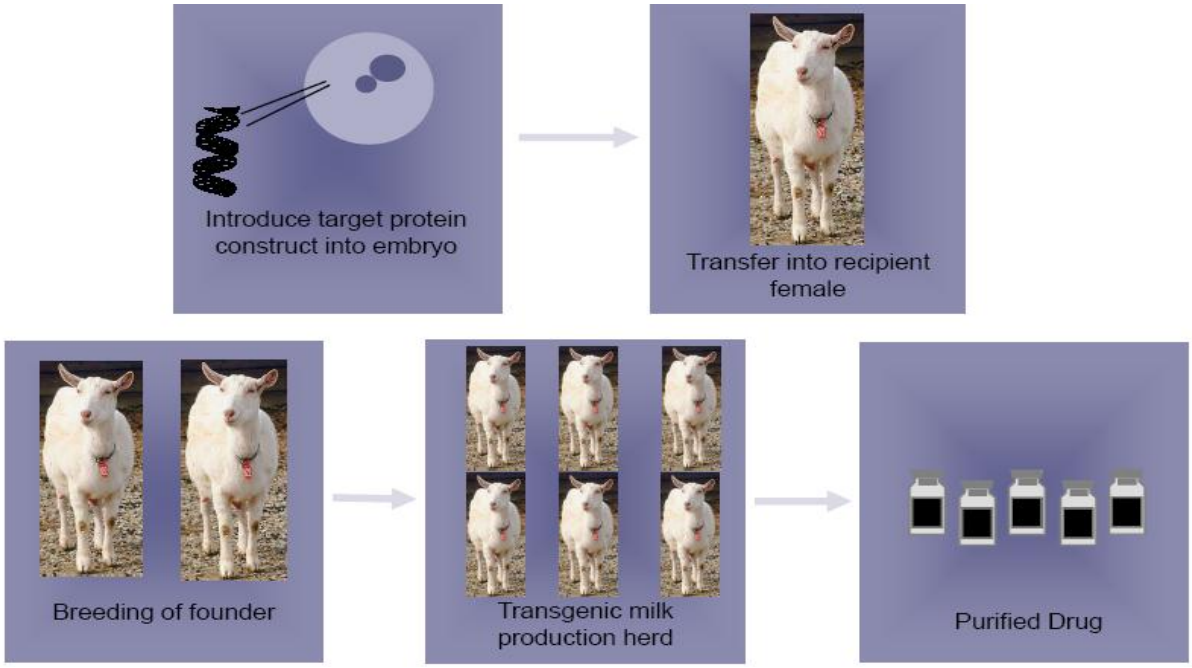
C. **Food**
   - Improved taste and nutrition
   - Improved handling qualities

D. **Industrial**
   - plants that produce plastics, fuels, and other products
   - plants for environmental cleanup

E. **Other**
   - pesticides made from naturally-occurring microorganisms and insects

Applications of biotechnology in agriculture (animals)

A. **Food**
   - Increased milk production



- leaner meat in pork
- growth hormones in farm-raised fish that result in earlier market-ready fish

B. Pharmaceuticals

- Animals engineered to produce human proteins for drugs, including insulin and vaccines

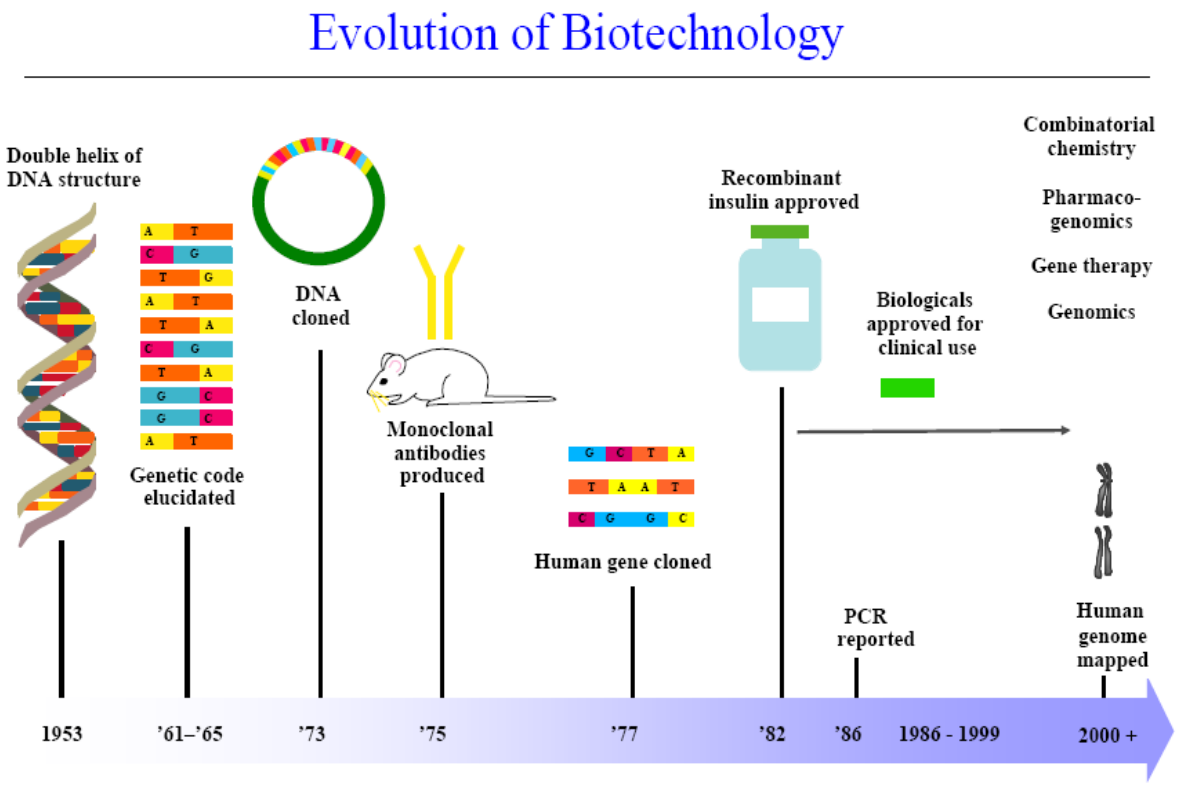
C. Breeding

- Disease tolerance
- Exact copies of desired stock
- Increased yields

D. Health

- Microorganisms introduced into feed for beneficial purposes
- Diagnostics for disease and pregnancy detection
- Animals engineered to produce organs suitable for transplantation into humans

History of biotechnology



1797: First vaccination. Edward Jenner takes pus from a cowpox lesion, inserts it into an incision on a boy's arm.

1830: Proteins are discovered.

1833: First enzyme is discovered and isolated

1865: Gregor Mendel discovers the laws of inheritance by studying flowers in his garden. The science of genetics begins.

1915: Phages — viruses that only infect bacteria — are discovered

1927: Herman Muller discovers that radiation causes defects in chromosomes.

1944: DNA is proven to carry genetic information by Oswald Avery, Colin MacLeod and Maclyn McCarty.

1953: James Watson and Francis Crick describe the double helical structure of DNA. They shared the 1962 Nobel Prize in Medicine or Physiology with Maurice Wilkins.

1955: The amino acid sequence of insulin is discovered by Frederick Sanger.

1958: DNA is made in a test tube for the first time. Sickle cell disease is shown to occur due to a change in one amino acid

1971: The first complete synthesis of a gene occurs. Discovery of *restriction enzymes* that cut and splice genetic material very specifically occurs. This opens the way for gene cloning.

1973: Stanley Cohen and Herbert Boyer perfect genetic engineering techniques to cut and paste DNA using restriction enzymes.

1975: Georges Kohler and Cesar Milstein develop the technology to produce monoclonal antibodies — highly specific, purified antibodies derived from only one clone of cells that recognize only one antigen. They shared the

1984: Nobel Prize in Physiology or Medicine with Neils Jerne.

1981: The first transgenic animals are produced by transferring genes from other animals into mice.

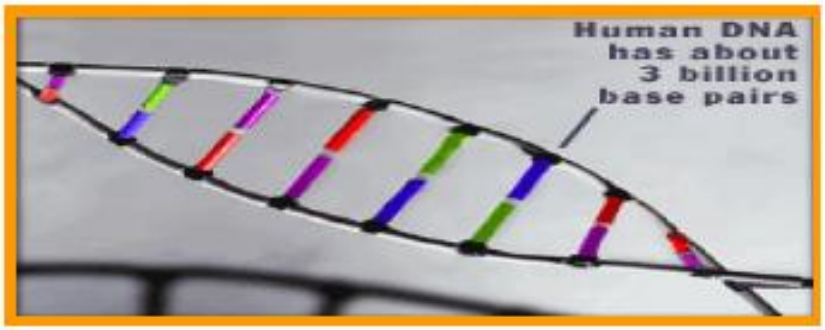
1983: The polymerase chain reaction (PCR) technique, which makes unlimited copies of genes and gene fragments, is conceived. Kary Mullis, who was born in Lenoir, N.C., wins the 1993 Nobel Prize in Chemistry for the discovery.

1986: First recombinant vaccine is approved for human use: hepatitis B. First anti-cancer drug is produced through biotech: interferon.

1987: First approval for field tests of a genetically modified food plant: virus-resistant tomatoes.

1994: Genetically modified tomatoes are sold in the U.S. for the first time.

1990: The Human Genome Project — an international effort to maps all of the genes in the human genome — is launched.
2002: The draft version of the human genome is published.
1997: Scientists report the birth of Dolly, the first animal cloned from an adult cell.
1998: Human embryonic stem cell lines are established. They offer hope to many because they may be able to replace diseased or dysfunctional cells.
2003: The SARS (severe acute respiratory syndrome) virus is sequenced three weeks after its discovery.
2004: The first cloned pet — a kitten — is delivered to its owner. She is called CopyCat (or Cc for short).
2006: A recombinant vaccine against human papillomavirus (HPV) receives FDA approval. The virus causes genital warts and can cause cervical cancer.



Source:

http://www.woodrow.org/teachers/bi/1993/intro.html

http://www.biotechno.netfirms.com/Biotechnology.htm

http://en.wikipedia.org/wiki/Genetic_engineering

http://en.wikipedia.org/wiki/Marker_assisted_selection

Questions

1. The term **"**Biotechnology" was first coined in ……

a) **1919** b) 1916 c) 1991 d) 1961

2. The term **"**Biotechnology" was first coined by …….

a) Neuberg b) Lipmann c) Frederick Sanger's d) **Karl Ereky**

3. Biotechnology is used in areas including ……..

a) Agriculture b) Bioremediation c) Food processing d) **All the above**

4. In agriculture, genetic engineering is being used to produce plants that are resistant to …….

a) insects b) weeds c) plant diseases d) **All the above**

5. Immunoassays are used for ……

a) drug level testing b) detection of unsafe levels of pesticides, herbicides and toxins on crops and in animal products

c) **both a anb b** d) None of the above

6. Genetic engineering is ……..

a) use of cellular enzymes to manipulate DNA b) Improve existing/create novel proteins to make useful products

c) Block or decrease the production of certain proteins d) Grow cells/tissues under laboratory conditions to produce an entire organism, or to produce new products

7. Protein engineering is ……..

a) use of cellular enzymes to manipulate DNA **b) Improve existing/create novel proteins to make useful products**

c) Block or decrease the production of certain proteins d) Grow cells/tissues under laboratory conditions to produce an entire organism, or to produce new products

8. Antisense or RNAi technology is ……..

a) use of cellular enzymes to manipulate DNA

b) Improve existing/create novel proteins to make useful products

c) Block or decrease the production of certain proteins

d) Grow cells/tissues under laboratory conditions to produce an entire organism, or to produce new products

9. Cell and tissue culture technology is ……..

a) use of cellular enzymes to manipulate DNA

b) Improve existing/create novel proteins to make useful products

c) Block or decrease the production of certain proteins

d**) Grow cells/tissues under laboratory conditions to produce an entire organism, or to produce new products**

10. Bioinformatics technology is ……..

a) use of cellular enzymes to manipulate DNA

b) Improve existing/create novel proteins to make useful products

c) Block or decrease the production of certain proteins

d) Computational analysis of biological data

11. Functional Genomics

a) **High-throughput approaches to determine the biological function of all of the genes and their products**

b) Improve existing/create novel proteins to make useful products

c) Block or decrease the production of certain proteins

d) Computational analysis of biological data

12. Translational genomics include(s)……

a) Transcriptomics alone

b) Proteomics alone

c) Metabolomics and Transgenomics

d) All the above

13. Metabolomics include(s) ……

a) Metabolite profiling

b) Chemical fingerprinting

c) Flux analysis

d) All the above

14. Various technologies applied in plant biotechnology includes …….

a) Genetic engineering/ recombinant DNA technology
b) Tissue culture
c) Molecular breeding - MAS
d) All the above

15. Vaccination was first attempted by ……

a) Gregor Mendel
b) Oswald Avery
c) Colin MacLeod
d) Edward Jenner

16. Vaccination was first attempted in the year……

a) 1797
b) 1777
c) 1787
d) 1767

17. Laws of inheritance was discovered by ……

a) Gregor Mendel
b) Oswald Avery
c) Colin MacLeod
d) Edward Jenner

18. The science of genetics was born in the year……

a) 1865
b) 1856
c) 1855
d) 1846

19. Phages infect ……

a) Only bacteria
b) Only viruse
c) Both a & b
d) None of the above

20. Name the scientist who discovered that radiation causes defects in chromosomes ……

a) Gregor Mendel
b) Oswald Avery
c) Colin MacLeod
d) Herman Muller

21. DNA is proven to carry genetic information by……

a) Oswald Avery
b) Colin MacLeod
c) Maclyn McCarty
d) All the above

22. DNA is proven to carry genetic information in the year ……

a) 1944 b) 1946

c) 1948 d) None of the above

23. Double helical structure of DNA is described by ……

a) James Watson b) Francis Crick

c) Both d) None of the above

24. The amino acid sequence of insulin is discovered by ……

a) James Watson b) Francis Crick

c) Frederick Sanger d) None of the above

25. Sickle cell disease occurs due to a change in ……..amino acid(s).

a) One b) Two

c) Three d) None of the above

26. The first complete synthesis of a gene occurred in the ……...

a) 1917 **b) 1971**

c) 1791 d) None of the above

27. Genetic engineering technique, to cut and paste DNA using restriction enzymes is perfected by ……..

a) Stanley Cohen b) Herbert Boyer

c) Both d) None of the above

28. The technology to produce monoclonal antibodies is developed by ……....

a) Georges Kohler b) Cesar Milstein

c) Both d) None of the above

29. …… developed the polymerase chain reaction (PCR) technique.

a) Kary Mullis b) Georges Kohler

c) Cesar Milstein d) None of the above

30. First recombinant vaccine approved for human use is ……...

a) hepatitis B b) polio

c) hepatitis C
d) None of the above

31. ……. is the first genetically modified plant approved for field tests.

a) virus-resistant tomatoes
b) virus-resistant brinjal
c) virus-resistant cotton
d) None of the above

32. Genetically modified tomatoes are sold in the U.S. for the first time in the year ……...

a) 1994
b) 1971
c) 1991
d) None of the above

33. The Human Genome Project is launched in ……. .

a) 1990
b) 1991
c) 2000
d) None of the above

34. The draft version of the human genome is published in ……..

a) 1990
b) 2000
c) 2002
d) 2004