Chapter - 12

Biotechnology and its applications

Biotechnology

The use of biology to develop technologies and products for the welfare of human beings is known as biotechnology. It has various applications in different fields such as therapeutics, diagnostics, processed food, waste management, energy production, genetically modified crops etc.

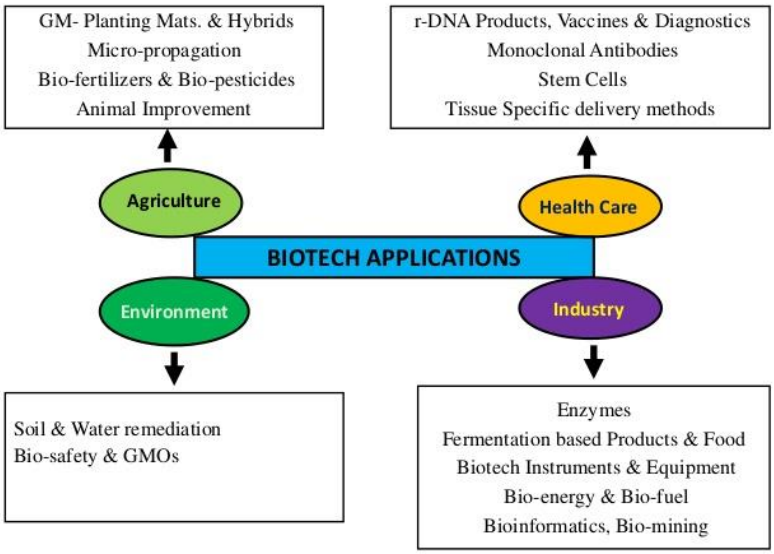

Fig.1. Different applications of biotechnology

Biotechnological application in agriculture

Biotechnology has different application in agriculture. It can be used in agro-chemicals, organic agriculture, and genetically engineered crop-based agriculture. It can be used to produce genetically modified organisms. Genetically modified organisms (GMO) can be obtained by alteration in their genetic material. Different application of genetically modified organisms is-

- Production of crops which are resistant to abiotic factors such as heat, cold, etc.
- Pest-resistant crops.
- Help to reduce post-harvest losses.
- Minerals can be used efficiently by the plants.
- Food with enhanced nutritional values.

The most important application in the field of biotechnology is the formation of pest resistant plants. *Bacillus thuringiensis* is a bacterium that produces a Bt toxin which has insecticidal activity. Gene that codes for Bt toxin can be isolated and inserted into the plant to provide insect or pest resistance.

Bt cotton: *Bacillus thuringiensis* produces certain proteins that can kill insects such as lepidopterans, coleopterans, and dipterans. They produce insecticidal protein, which when enter the body of the insect will become active. This toxin when binds to the midgut produces causes cell to swell and eventually death of the insect. These Bt genes are isolated and inserted into cotton plants. Such cotton is known as Bt cotton. The gene that codes for insecticidal protein is known as cryIAc and cryIIAc.

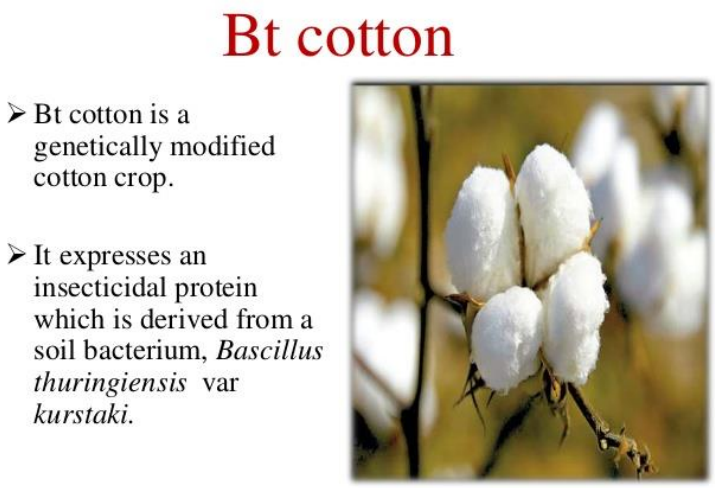

Fig.2. Bt cotton

Pest resistant plants

Various pests affect the plants which causes loss as well as decrease in the yield of the plant. A nematode *Meloidegyne incognitia* infects the roots of tobacco plants and causes a decrease in the yield of the plant. To prevent this, **RNA interference** technology was used. This method involves silencing of a specific mRNA due to a complementary dsRNA molecule. This inhibits the translation of the mRNA.

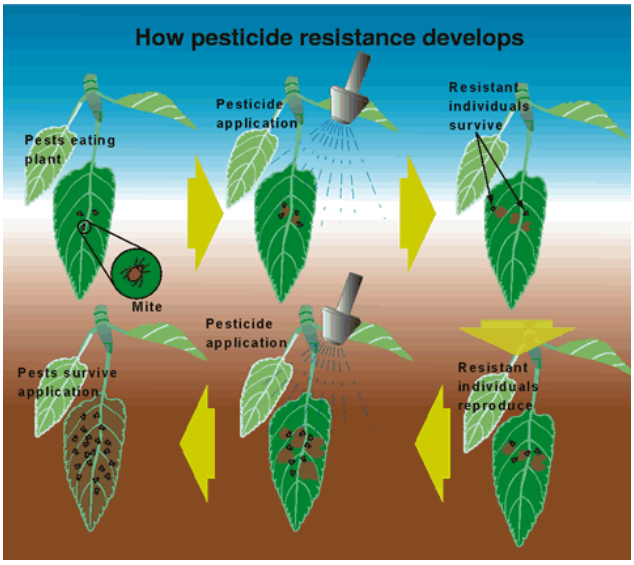

Fig.3. Development of pesticide resistant plants

Biotechnology applications in medicine

Biotechnology has contributed a lot in medicine industry. The use of biotechnology in medicine is known as medicinal biotechnology. They provide methods for the formation of genetically modified insulin known as **humulin**. This helps in treatment of large number of diabetes patients. Earlier insulin was extracted from the pancreas of the slaughtered animals such as cattle and pigs. Such insulin has chances to cause allergies to humans. The most important issue with the production of insulin is formation of mature and assembled insulin.

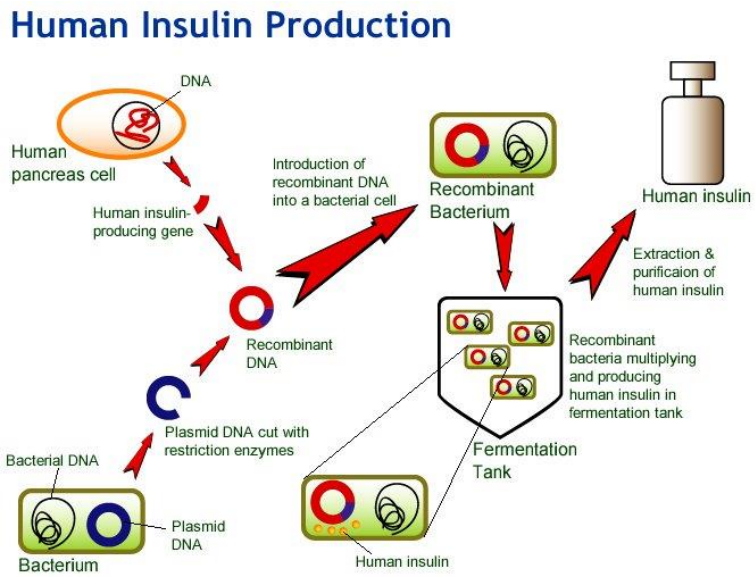

Fig.4. Human insulin production

Gene therapy

To correct the heredity diseases, gene therapy is used. The correction of gene defects is known as gene therapy. A normal gene is inserted into the individual or in an embryo to replace the abnormal gene. The first gene therapy was given to a 4-year-old girl in 1990 for Adenosine deaminase deficiency. Earlier, bone marrow transplantation and enzyme replacement therapy were used to treat adenosine deaminase deficiency. But both strategies are not completely curative.

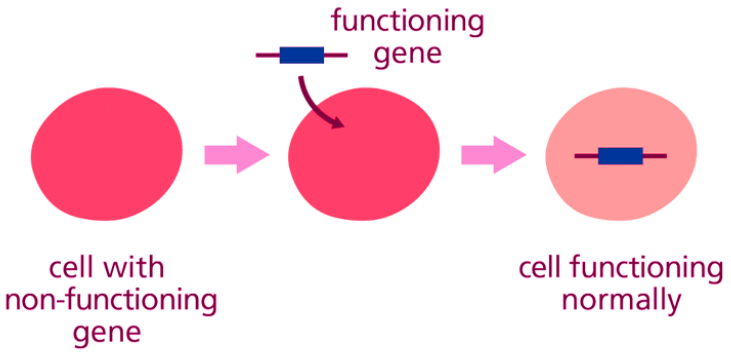

Fig.5. Gene therapy

Molecular diagnosis

It helps in disease diagnosis by various techniques such as ELISA, PCR, and recombinant DNA technology. ELISA (enzyme linked immunosorbent assay) is based on antigen and antibody reaction to detect different diseases. PCR (polymerase chain reaction) is technique to amplify specific DNA segment. This helps to detect HIV in AIDS patients.

Transgenic animals

Animals that have their DNA manipulated are known as transgenic animals. For example, rats, rabbits, pigs, sheep etc. These animals help to understand how genes are regulated and how they help in development of animals. It helps to study how genes are responsible for the development of various diseases. They can be used to manufacture chemicals that are useful. They can also be used for testing of drugs and vaccines.

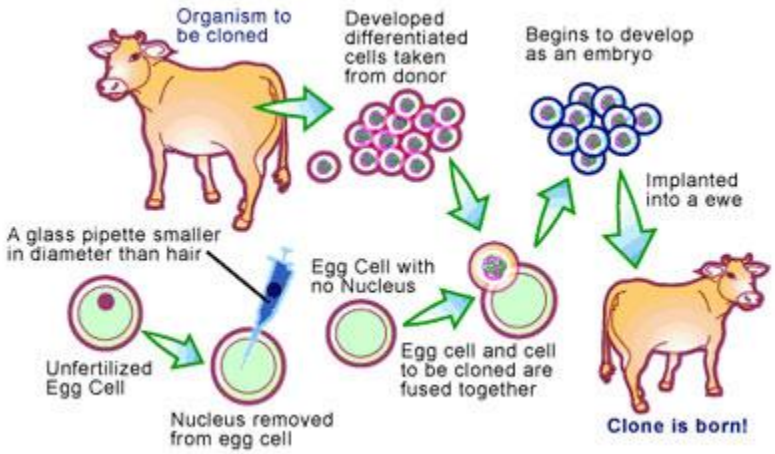

Fig.6. Formation of transgenic animals

Biotechnology in production of antibiotics

Plants are used to develop antibiotics for humans as well as for animal use. It helps in production of antibiotics, vaccines and artificial hormones for hormone therapies.

Ethical Issues:

1. The manipulation of living organisms by man is similar to man "playing God". It is a tool with great power and therefore, immense responsibility.
2. The genetic modification of any organism is not always completely predictable. It may lead to problems in the organism.
3. The impact of introduction of a GMO into an ecosystem is not completely known. It could have unpredictable results.

GEAC: Genetic Engineering Approval Committee is a committee set up by the Indian Government to oversee all decisions regarding GM research and the safety of GMOs for public use.

Biopiracy: Use of bio-resources by commercial and multinational companies and other organizations without the appropriate authorization and permission from the countries and people concerned without making the compensatory payment.