

29 Jan 2026

CHAPTER - 10 Biotechnology and its Applications.

★ INTRODUCTION :

- Major areas of application of biotechnology are
 - 1) Agriculture
 - 2) Energy and environment.
 - 3) Health and pharmaceuticals.
 - 4) Medical Diagnosis
 - 5) food and fermentation
 - 6) In formation of GMO's (Genetically Modified Organisms).

• ★ The research areas of biotechnology are -

- 1) Providing best catalyst in the form of improved organisms - Usually microbes or pure enzyme.
- 2) Create optimum conditions through engineering for a catalyst to act.
- 3) Downstream technologies to purify the protein / organic enzymes.

Application of Biotechnology in Agriculture :

- To increase quality and quantity of crop yield, biotechnology is used.
 - Agriculture is basically three types -
 - 1) Agro-chemical agriculture.
 - 2) Organic Agriculture.
 - 3) Genetically Engineered Agriculture.
- Agro chemical Agriculture - Use of fertilisers, pesticides, weedicides, etc.

- 2) Organic Agriculture - Natural growth of the crop without using any chemical.
- 3) Genetically Engineered Agriculture - With the help of biotechnology and alteration of genes.

GREEN REVOLUTION :-

- It was started in Mexico by Norman Borlaug*.
- In India, MS Swaminathan started green revolution and he is known as FATHER OF GREEN REVOLUTION in India.
- It is collection of techniques to increase crop yield like -
 - i) Supply of good quality seeds, pesticides, weedicides and fertilisers.
 - ii) Proper irrigation facilities provided to farmers.
 - iii) Proper arrangement to sell out crop products.
 - iv) It result tripling* of the yield.

Drawbacks -

- Used chemicals were expensive and hazardous.
- Crops were not resistant.
- They could not produce very high yield of crop.
- So, there was a need for better technique to avoid use of chemicals and generate resistance.

★ GENETICALLY MODIFIED ORGANISMS :-

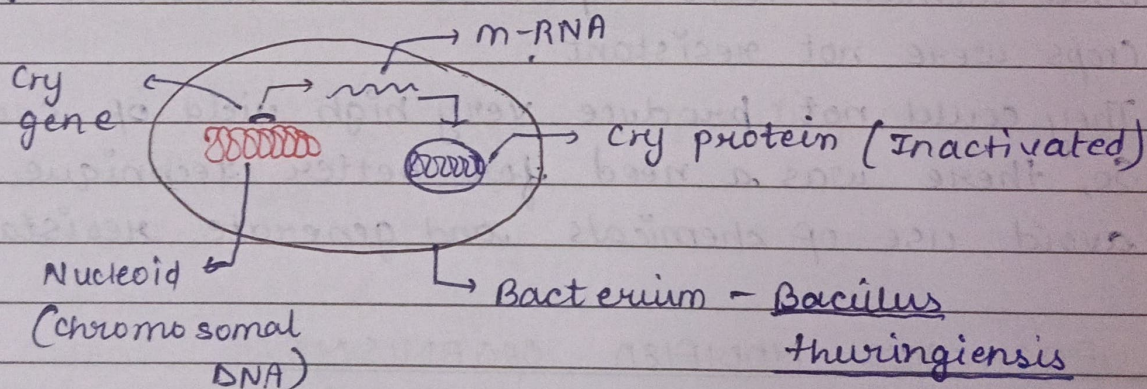
→ They can be - Bacteria, fungi, Plants and Animals.

Genetically Modified Plants : (Transgenic plants)

- Transgenic plants are those plants, the gene is modified according to desired result.
- Advantages of transgenic plants are -
 - i) Plants get tolerance against abiotic stress like heat, cold, drought, flood and salt concentration.
 - ii) Plants become pest resistant.
 - iii) Dependency of plant for pesticides is reduced.
 - iv) Post harvest control result decrease in post harvest losses.
 - v) Increase Nutritional value of crop.
 - vi) Increase efficiency of minerals uses to prevent soil from exhaust.
 - vii) Creation of tailor made plants for alteration of resources like starch, fuel, etc.

⇒ Use of Bt toxin in transgenic plants -

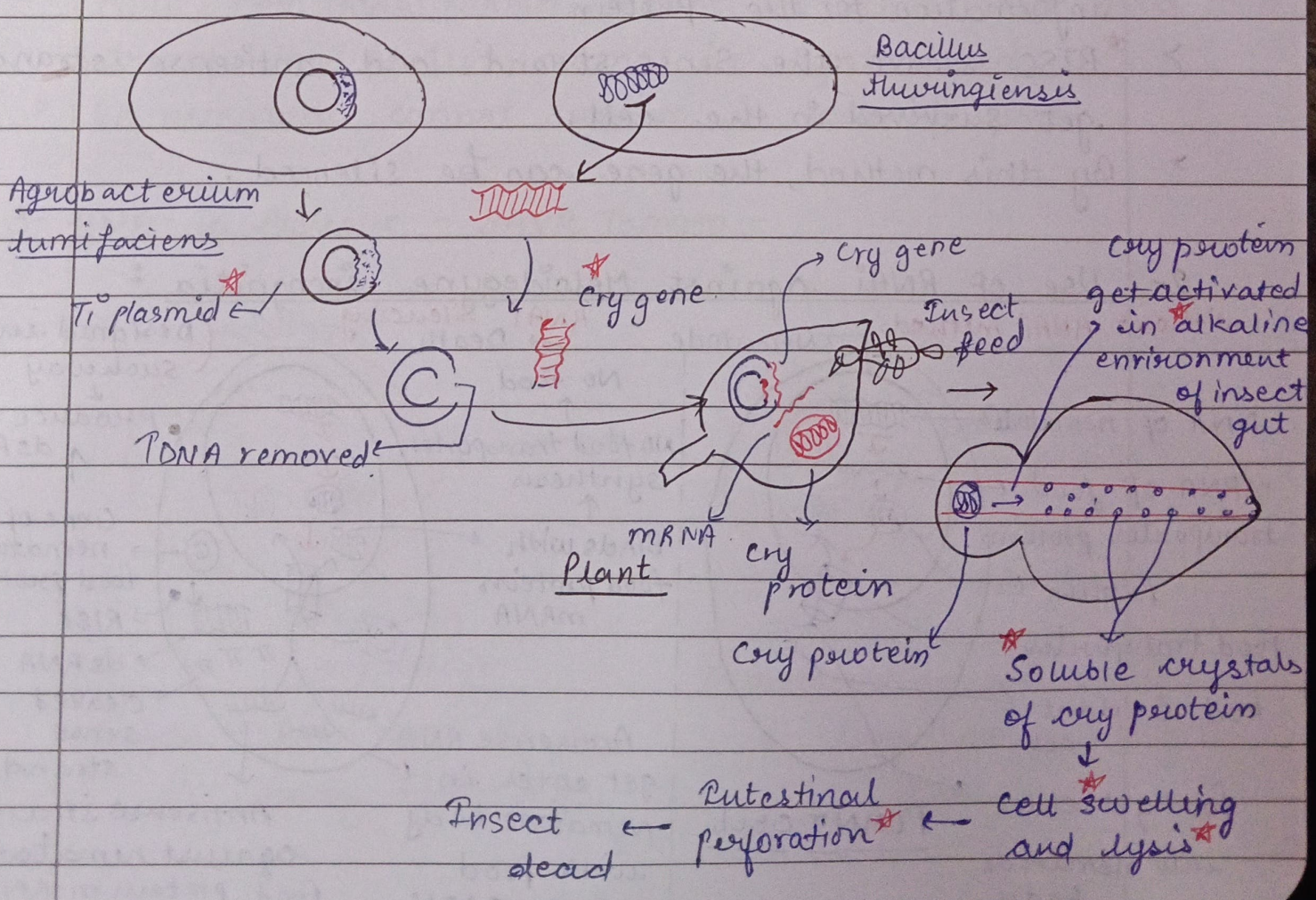
1) What is Bt toxin?



- > Some strain of bacteria Bacillus thuringiensis produce cry proteins known as Bt toxins.
- > They are endotoxins and remain inactive in bacterial cell.

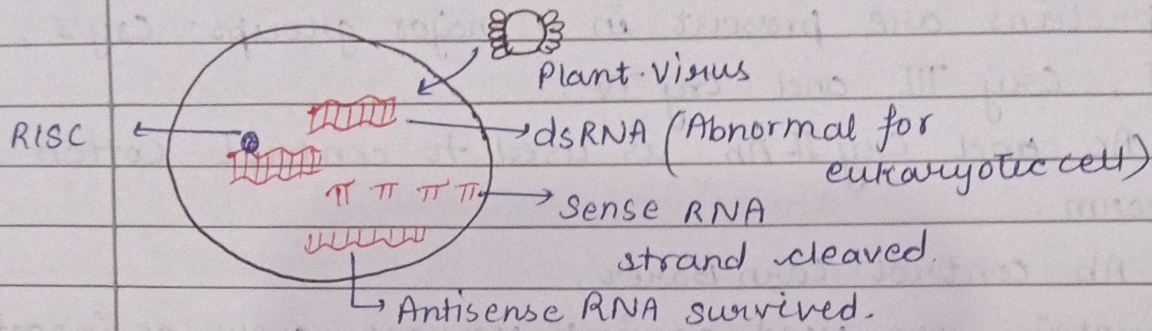
- > If they are exposed to alkaline medium (gut of insect) then they produce ~~insoluble~~ crystals which create pores in insect gut.
- > It result death of insect because of lack of nutrition.
- > Cry proteins are present in 4 major groups - Cry I, Cry II, Cry III and Cry IV.
- > Cry I Ac and Cry II Ab is used to control Cotton Bollworm.
- > Cry I Ab control Corn Boxer.
- > Cry proteins are used against various group of insects.
- ★ 1) Order Lepidoptera = Cotton bollworm, Army worm, Corn Boxer, Tobacco budworm.
- ★ 2) Order Coleoptera = Beetles.
- ★ 3) Order Diptera = flies and Mosquito.

2) How Bt toxin work as insecticide ?



⇒ Use of RNAi method (RNA Interference) :

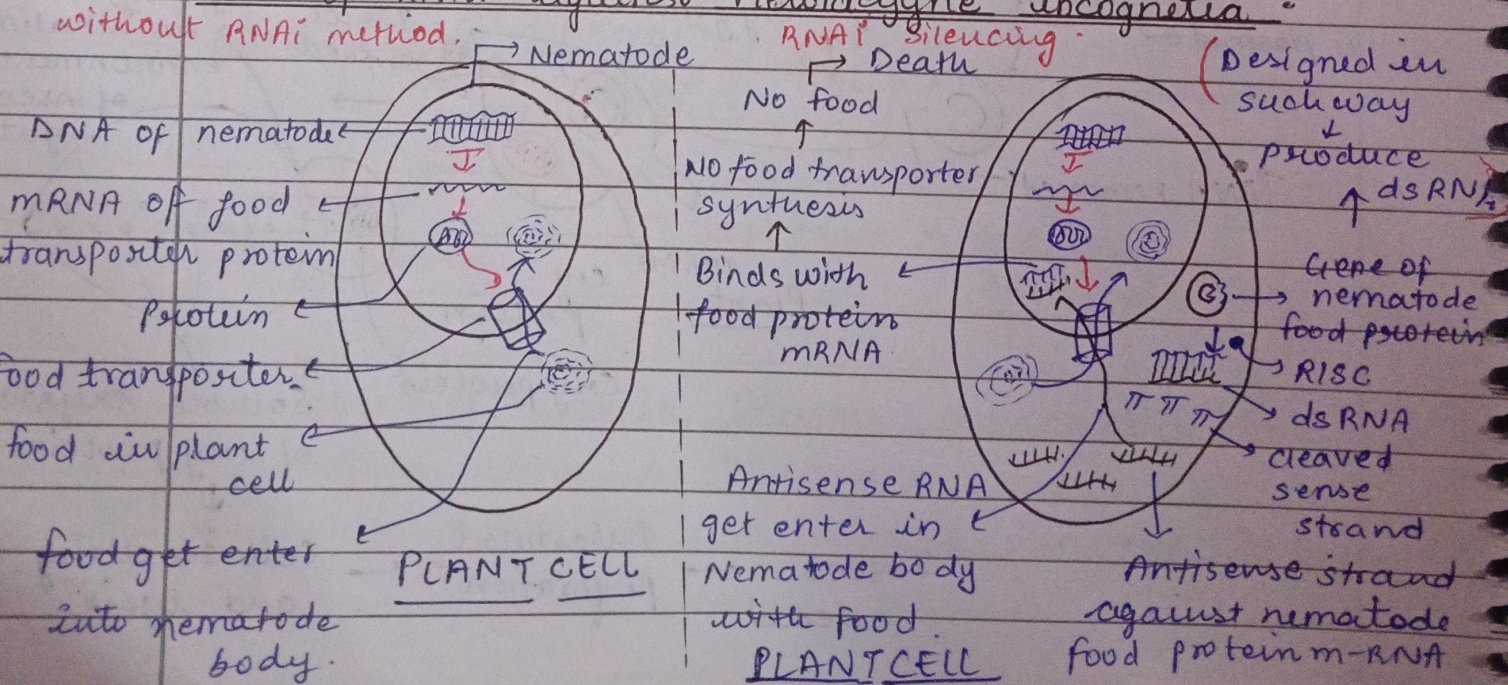
1- What is RNAi ?



Eukaryotic cell - plant cell.

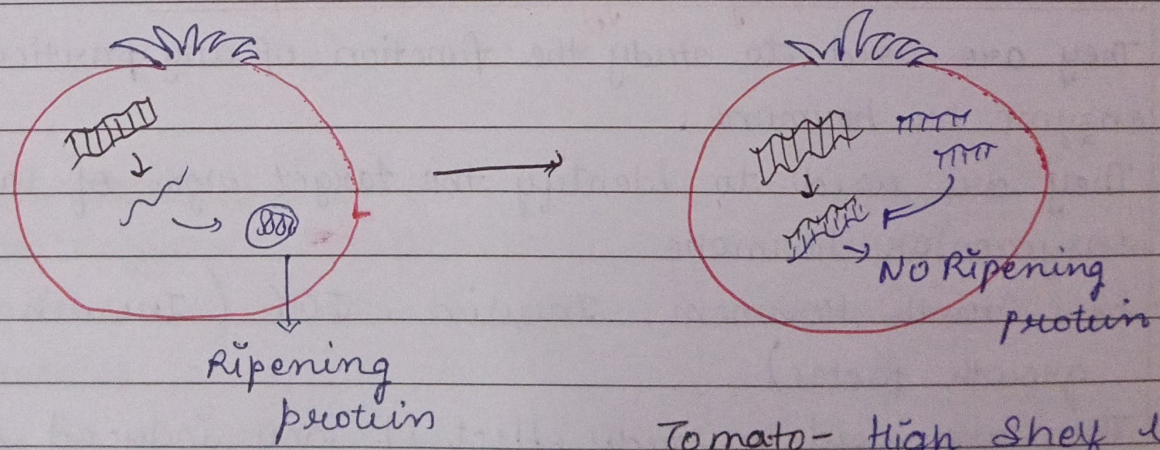
- > Eukaryotic cells have specific protein complex with siRNA known as **RISC** (RNA Inducing Silencing complex)
- > When dsRNA is present inside the cell then **RISC** always binds with sense strand of dsRNA.
- > Sense strand is major RNA strand which has coding information for the protein.
- > **RISC** cleave the sense strand and antisense strand get survived in the cell.
- > By this method, the gene can be silenced.

2- Use of RNAi against Meloidogyne incognita :



- > *Meloidogyne incognita* is pathogen of Tobacco plant.
- > It codes for a food transporter protein for transport of food from plant into nematode body.
- > So, RNAi method was used to silent mRNA or encoding food transporter protein of nematode.
- > The gene of food transporter protein was designed to produce dsRNA.
- > It was incorporated with Ti plasmid and introduced in tobacco plant.
- > As dsRNA was produced in tobacco plant, RISC cleave sense RNA.
- > So, there were many antisense strand against mRNA of food transporter protein.
- > When nematode infect this plant then these antisense RNA get enter into nematode body, bind with nematode's mRNA.
- > Now, nematode mRNA cannot be translated and food transporter protein cannot be synthesised.
- > So, nematode cannot survive in lack of food.

3- RNA in flavour - SAVR Tomato -



Tomato - less shelf life.
 - Early ripening.

Tomato - High Shelf life.
 - Late / NO ripening.

★ GOLDEN RICE :

- People of coastal areas are majorly dependent on rice for their major meal.
- Rice do not have abundant source of Vitamin A so, the people suffered from vitamin A deficiency and night blindness.
- So, the gene encoding β -carotene (Crt I) was introduced into paddy plant.
- So, colour of the rice grain turned into yellowish - Golden rice. (Vitamin A enriched)

Genetically Modified Animals : (Transgenic animals)

- Those animals which are genetically modified, called as TRANSGENIC ANIMALS.
- Transgenic animals may be - Monkey, Rats, Guinea Pig, hence fishes, cow, buffalo and sheep.
- About 95% of all transgenic animals are Rats.

⇒ Advantages of Transgenic Animals :

1) For Normal Physiology and Development :

- They are used to study the function of any particular enzyme or hormone.
- They are used to identify the target organ of any enzyme or hormone.
- Ex - Growth Hormone, Insulin, IGF (Insulin like growth factor).
- They are used to study effect of any induced gene.

cystic fibrosis block activity of CFTR

CFTR \rightarrow pumps
pumps Cl^- .

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2) for study of Diseases :

- Transgenic animals are used to study symptoms of many diseases like cystic fibrosis, Rheumatoid Arthritis, Phenylketonuria, Cancer.

3) for clinical Testing and chemical Testing :

- clinical trials of vaccines, medicines or any food material for the safety of humans.
- firstly, the effect of any medicine (vaccine) is examined on transgenic animals. (Thymus removed)

4) for Desired product :

Buffalo, cow = Milk

Sheep = wool

Hens = Eggs

Cocks = meat

He Goats = Meat

fishes = meat, Liver Oil.

Rosie Cow :

- first transgenic cow developed in 1997.
 - produce milk enriched in human milk protein. - α -lactalbumin
- * (2.4 gm per litre)

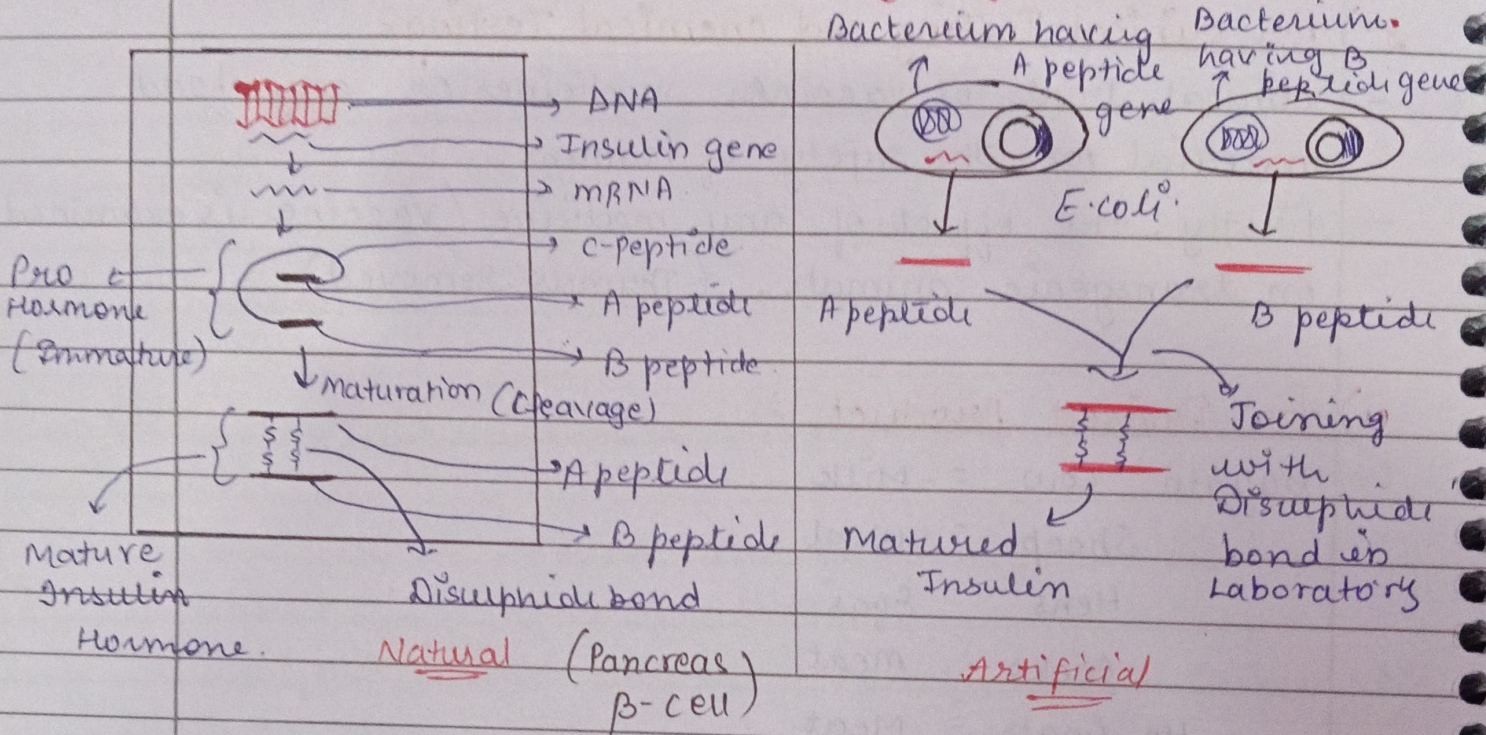
α -1-antitrypsin :

- This enzyme inhibit release of elastase from WBC.
- Elastase digest elastin fibres in alveoli and damage alveolar cells.
- So, if α -1 antitrypsin is not coded by DNA then elastase enzyme digest elastin \rightarrow Alveoli are damaged and cause Emphysema.

Note- So, α -1 antitrypsin is prepared in Sheep milk

⇒ Application of Biotech in Medical Industry:

Artificial Insulin / Genetically engineered insulin:



- Naturally, insulin is synthesised as a pro-hormone -

> A peptide = 21 amino acids. > C-peptide = 31 amino acids

> B peptide = 30 amino acids.

> During maturation, C-peptide is cleaved, only A and B peptide is present in mature insulin.

> Both peptide are joined together with Disulphide bonds

→ Insulin Deficiency and its Supply -

- Lack of insulin result Hyperglycemia (Diabetes Mellitus)

- Previously, insulin was isolated from cattles and pigs.

- But foreign protein trigger strong immune response in human body and large no. of animals were harmed to isolate insulin.

→ Artificial Insulin :

- In 1983, an American company Eli Lilly synthesised A peptide and B-peptide in separate bacterium = E. coli.
- Both peptides were isolated and joined together with disulphide bond in lab.

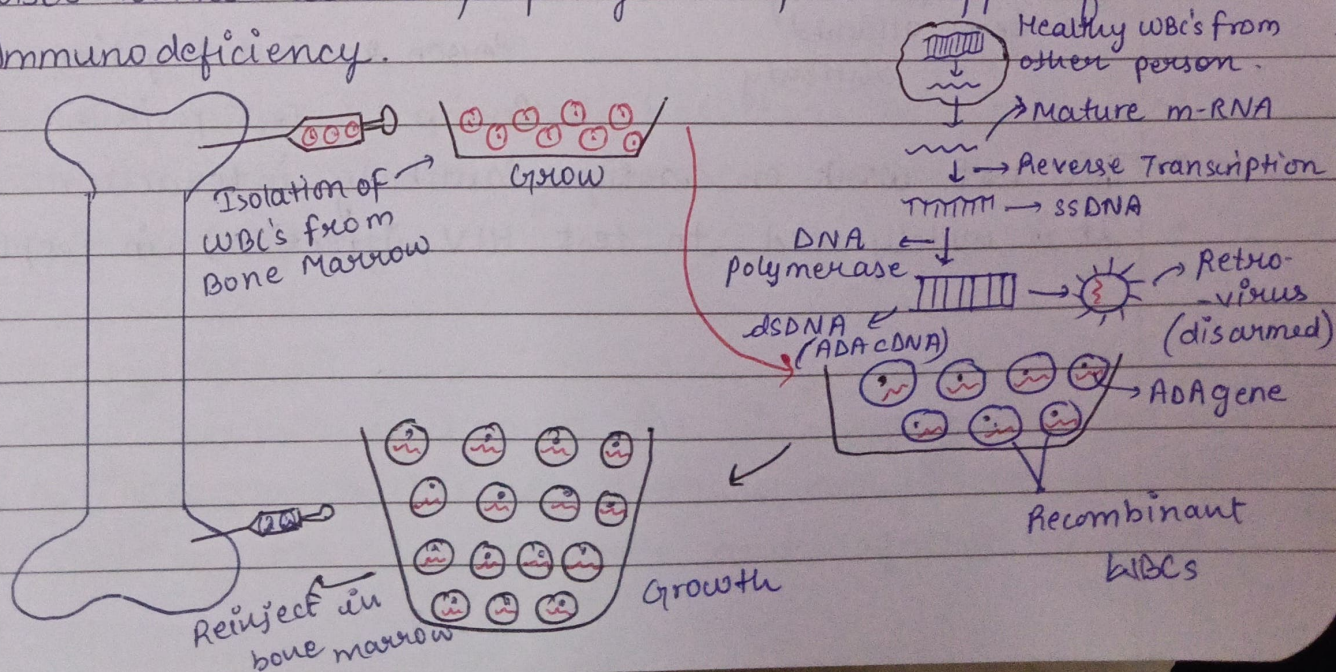
Note: Apart from insulin, about 30 drugs are approved from which 12 are present in market which are produced by recombinant DNA technology.

Gene Therapy :

- Treatment of any disease by introduction of a gene is called as GENE THERAPY.

→ ADA Gene Therapy -

- firstly, it was given in 1990 to 4 year girl child suffering from ADA deficiency.
- ADA gene in WBC's code for an enzyme Adenosine Deaminase.
- This enzyme remove toxins from WBC's so that they can work efficiently.
- If ADA enzyme is not coded, ADA gene is defective then WBC's cannot work properly and person suffer from severe Immunodeficiency.

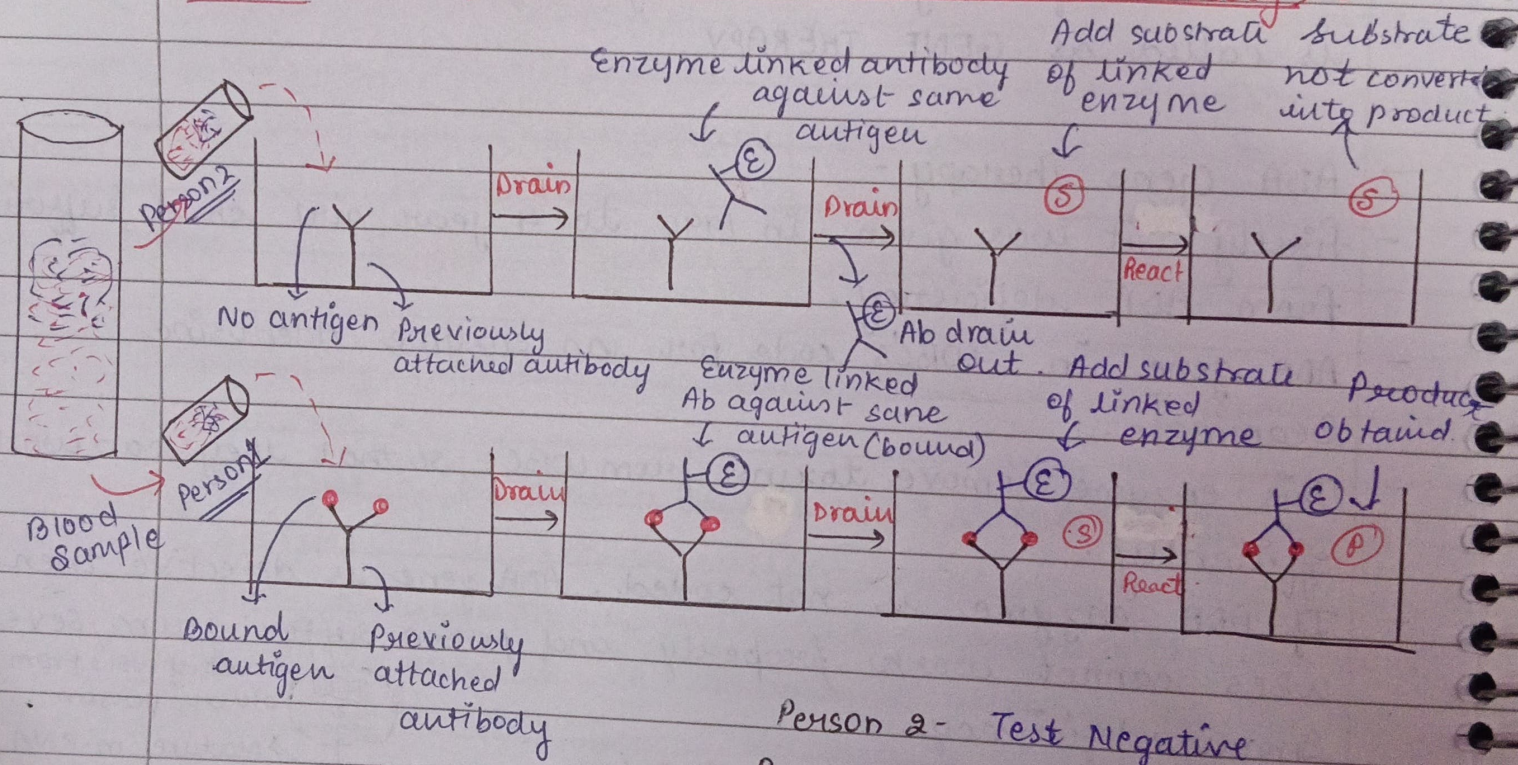


- Previously, enzyme therapy and bone marrow transplant were given but they were not long-lasting.
- Gene Therapy is long lasting but not permanent cure because WBCs die after sometime.
- If gene therapy is given in [★] stem cell of [★] embryo then it can be permanent cure.

⇒ Medical Diagnostic Techniques :

1- PCR → Previous chapter.

2- ELISA (Enzyme Linked Immuno Sorbent Assay) :



Person 2 - Test Negative

Person 1 - Test Positive

- This test work on antigen antibody interaction.
- It is widely used to test HIV infections in people.

★ ETHICAL ISSUES :

- Ethical issue is a situation that involve immoral conflict or disagreement against any wrong step.
- "The patent" is a set of exclusive rights issued by National Government to original Inventor.
- In India, "GEAC (Genetic Engineering Approval Committee)" take decision about genetically modified organism.

Biopiracy :

- Use of bioresources without proper information and compensatory payment is called Biopiracy.
- Biopiracy is seen in developing countries because they are rich in bioresources and developed countries exploit these bioresources.
- To avoid biopiracy, Indian Parliament passed an Amendment

Major Controversies of Patents in India :

1) Turmeric :

- Patent of turmeric for anti-inflammatory properties was issued by US Government to an American company.

2) Neem :

- Patent of Neem for its anti-bacterial and medicinal properties was issued by European Government to an European company.

3) Basmati Rice :

- Indian Basmati is known for its long grain and aroma.
- About 2,00,000 varieties of Basmati are present in which 27 varieties are documented and grown in India.

Revoked = Vapis Jena.

- US people crossed Indian Basmati with their dwarf variety of rice and shown it as their invention.
- US Government issued patent of Basmati to an American company in 1997.*

Note : Indian scientist challenged all patents in the court and revoked it.

★ STEM CELL :

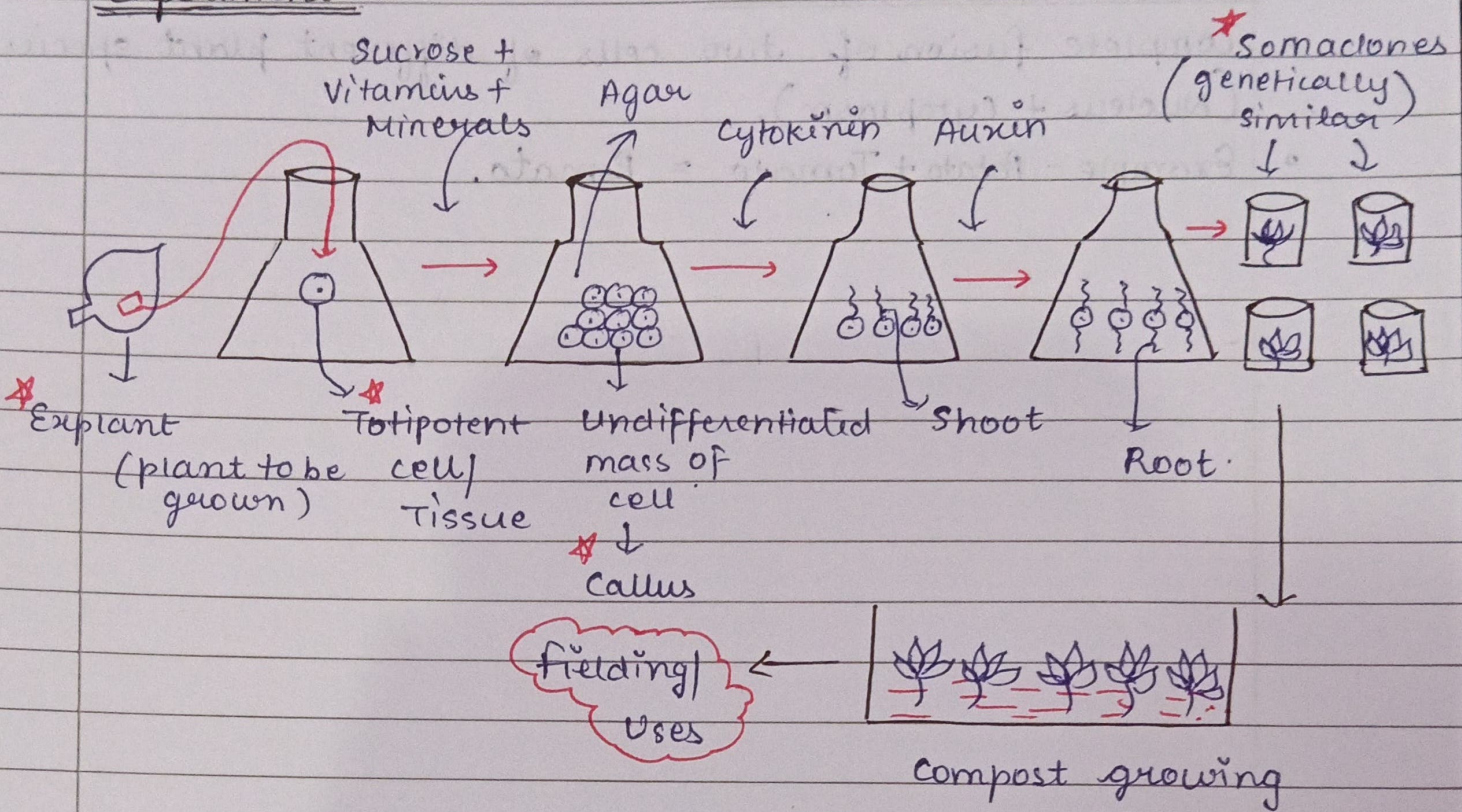
- * Undifferentiated cell which has capacity to divide and produce different type of cells, is called Stem cell.
- This capacity of stem cell is called TOTIPOTENCY.

★ PLANT TISSUE CULTURE :

Requirements :

- 1- Explant - Plant to be grown
 - 2- Agar. → Solid growing medium - Agar
 - 3- Sucrose, Vitamins, Minerals.
 - 4- Growing/Growth Hormones
 - Auxins
 - Cytokinins
 - 5- * Darkness.
 - 6- Temperature around 24°C (for optimum enzyme activity)
- formation of plants with the help of plant tissue culture on a large scale is called * MICROPROPAGATION.
 - Plant tissue culture is based upon Totipotency.
 - Somaclones are 100% genetically similar which can be further used in experiments or transfer into fields after some days of compost growing.

⇒ Experiment :



• Ex-Potato, Banana, Apples are used to make Compost.

Parts of plant used in Tissue Culture

Apical Meristem	Pollen cells / Anther	Embryo
- Apical meristem is free from virus because it do not have vascular tissue.	- Culture of pollen cell takes place to obtain pure homozygous line like TT or tt.	- Embryo of plant is grown in the laboratory in case of seed dormancy or plant abortion during hybrid cross fertilisation.
- Virus travel in the plant by vascular tissue.	- The pollen grain is cultured.	
- So, culture of virus free plants takes place by collecting the cells from apical meristem.	- for doubling of chromosomes to make diploid cell from haploid pollen grain, a chemical is used = colchicine.	
- Ex- Sugarcane	- Colchicine inhibit form ⁿ of spindle fibres and segregation of chromosomes.	

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★ SOMATIC HYBRIDISATION :

- Complete fusion of two cells of different plant species (Nucleus + cytoplasm).
- Example - Potato + Tomato = Pomato.