BASIC PRINCIPLES OF GENETIC ENGINEERING

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WHAT IS A GENE ?

- A Gene is a **fundamental**, **physical** and **functional** unit of heredity.

- It is responsible for the **physical** and **inheritable** characteristics of an organism.

DEFINITION

- Genetic Engineering is **manipulation/alteration** of structure of a gene to create a desired characteristic in an organism.

- Genetic recombination technology consists of the breakage and joining of DNA molecules.

- Genetically engineered DNA prepared by transplanting or splicing genes from one species into the cells of a host organism of a different species. Such DNA becomes part of the host's genetic makeup and is replicated.

- Genetic engineering primarily involves the manipulation of genetic material (DNA) to achieve the desire goal in pre determined way.

- If genetic material from another species is added to the host, the resulting organism is called transgenic.

- Genetic engineering can also be used to remove genetic material from the target organism, creating a knock out organism.
- Genetic engineering, sometimes called genetic modification, is the process of altering the DNA in an organism's genome.
- This may mean changing one base pair (A-T or C-G), deleting a whole region of DNA, or introducing an additional copy of a gene.
- It may also mean extracting DNA from another organism's genome and combining it with the DNA of that individual.

- Plants, animals or micro organisms that have been changed through genetic engineering are termed genetically modified organisms or GMOs.
- If genetic material from another species is added to the host, the resulting organism is called transgenic.
- If genetic material from the the resusame species or a species that can naturally breed with the host is used lting organism is called cisgenic.
- If genetic engineering is used to remove genetic material from the target organism the resulting organism is termed a knockout organism.

HISTORY

- Genetic engineering as the direct manipulation of DNA by humans outside breeding and mutations has only existed since the 1970s.
- The term "genetic engineering" was first coined by Jack Williamson in his science fiction novel Dragon's Island, published in 1951.

- In 1973 **Herbert Boyer and Stanley Cohen** created the first transgenic organism by inserting antibiotic resistance genes into the plasmid of an *E.coli* bacterium. In 1974, the same techniques were applied to mice.

- The first trials of genetically engineered plants occurred in France and the USA in 1986, tobacco plants were engineered to be resistant to herbicides.

- Genetic engineering has a number of useful applications, including scientific research, agriculture and technology.
- In plants, genetic engineering has been applied to improve the resilience(illness), nutritional value and growth rate of crops such as potatoes, tomatoes and rice.
- In animals it has been used to develop sheep that produce a therapeutic protein in their milk that can be used to treat cystic fibrosis, or worms that glow in the dark to allow scientists to learn more about diseases such as Alzheimer's.

TRANSGENIC PLANTS

- The Flavr Savr tomato was a tomato engineered to have a longer shelf life.

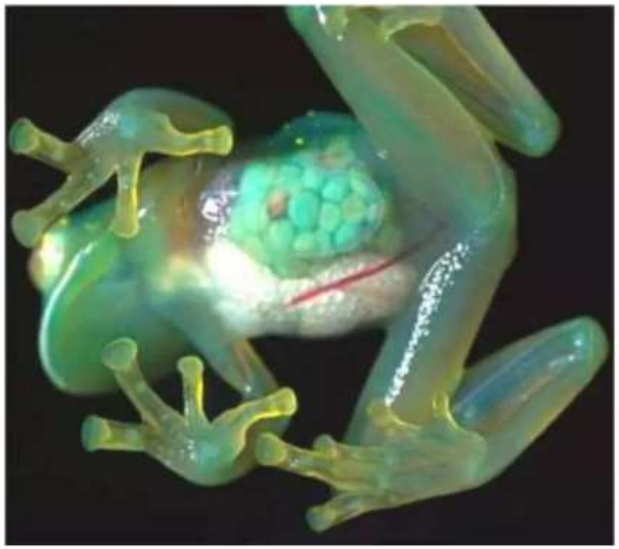
- Bt-Cotton is a genetically modified cotton which is resistant to pests.

- Golden Rice genetically modified to contain beta-carotene (a source of Vitamin A).

- A Blue Rose is a genetically modified Rose.

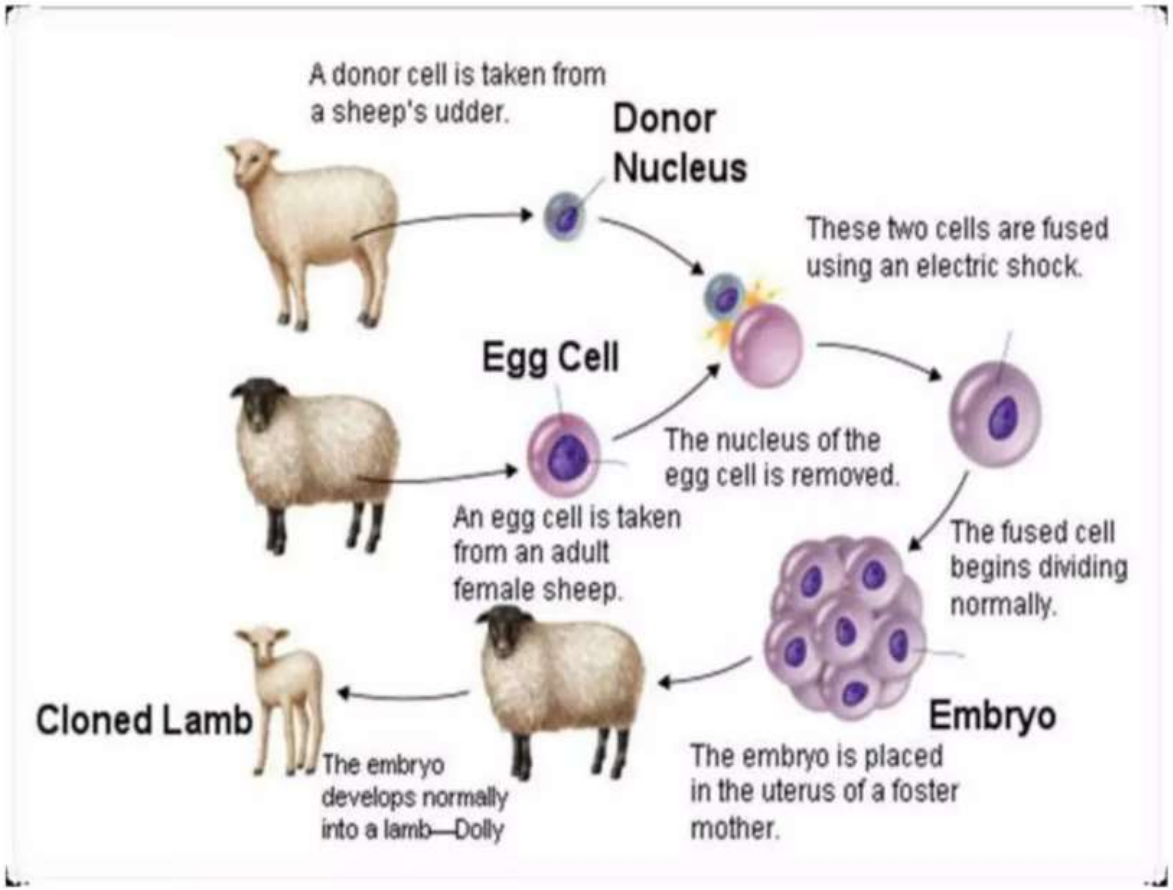
TRANSGENIC ANIMALS

- It's a miracle of genetic engineering. You can see through the skin how organs grow, how cancer starts and develops without dissecting the Frog.



- The Glow Fish was the first genetically modified animal to become available as a pet. It is a natural Zebrafish which has genetic information from bioluminescent jellyfish added to its DNA.

DOLLY THE SHIP



- Dolly the sheep is the world's most famous clone.
- Dolly was born 5 July 1996 to three mothers (one provided the egg, another the DNA and a third carried the cloned embryo to term).

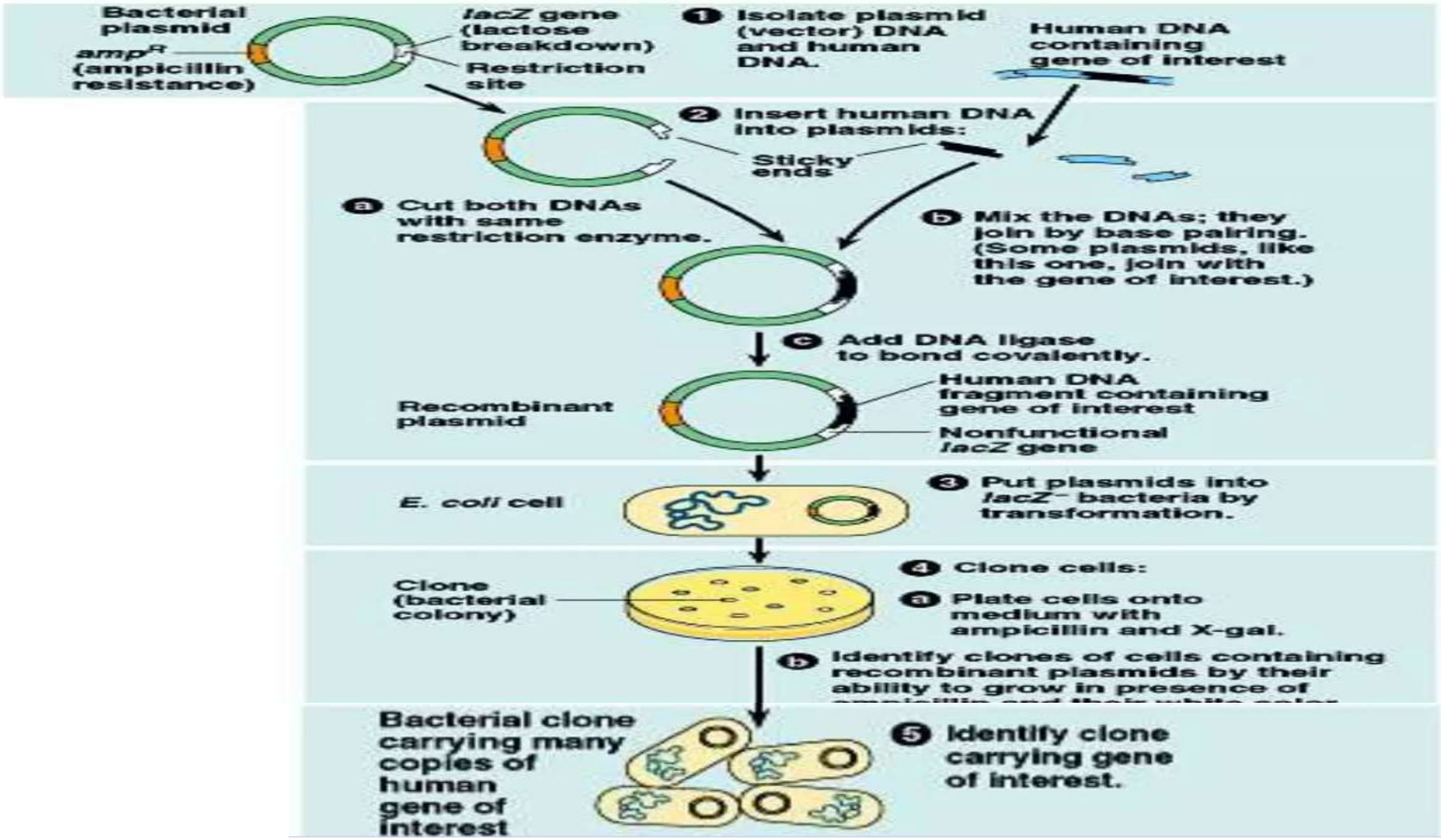
- **Host organism :** The organism that is modified in a genetic engineering experiment is referred to as the host. Depending on the goal of the genetic engineering experiment, the host could range from a bacterial cell to a plant or animal cell or even a human cell.
- **Vector :** The vehicle used to transfer genetic material into a host organism is called a vector. Scientists typically use plasmids, viruses, cosmids (cos+plasmids), or artificial chromosomes in genetic engineering experiments.

Example

- To help explain the process of genetic engineering lets take the example of insulin, a protein that helps regulate the sugar levels in our blood.
- Normally insulin is produced in the pancreas, but in people with type 1 diabetes there is a problem with insulin production.
- People with diabetes therefore have to inject insulin to control their blood sugar levels.
- Genetic engineering has been used to produce a type of insulin, very similar to our own, from yeast and bacteria like E. coli.
- This genetically modified insulin, 'Humulin' was licensed for human use in 1982.

PROCESS

1. A small piece of circular DNA called a plasmid is extracted from the bacteria or yeast cell.
2. A small section is then cut out of the circular plasmid by restriction enzymes, 'molecular scissors'.
3. The gene for human insulin is inserted into the gap in the plasmid. This plasmid is now genetically modified.
4. The genetically modified plasmid is introduced into a new bacteria or yeast cell.
5. This cell then divides rapidly and starts making insulin.
6. To create large amounts of the cells, the genetically modified bacteria or yeast are grown in large fermentation vessels that contain all the nutrients they need. The more the cells divide, the more insulin is produced.
7. When fermentation is complete, the mixture is filtered to release the insulin.
8. The insulin is then purified and packaged into bottles and insulin pens for distribution to patients with diabetes.


Bacterial plasmid
ampR (ampicillin resistance)
lacZ gene (lactose breakdown)
Restriction site
1 Isolate plasmid (vector) DNA and human DNA.
Human DNA containing gene of interest
2 Insert human DNA into plasmids:
Sticky ends
a Cut both DNAs with same restriction enzyme.
b Mix the DNAs; they join by base pairing. (Some plasmids, like this one, join with the gene of interest.)
c Add DNA ligase to bond covalently.
Recombinant plasmid
Human DNA fragment containing gene of interest
Nonfunctional lacZ gene
E. coli cell
3 Put plasmids into lacZ− bacteria by transformation.
Clone (bacterial colony)
4 Clone cells:
a Plate cells onto medium with ampicillin and X-gal.
b Identify clones of cells containing recombinant plasmids by their ability to grow in presence of
Bacterial clone carrying many copies of human gene of interest
5 Identify clone carrying gene of interest.

Applications of Genetic Engineering

- **In Medicine:** Genetic engineering can be applied to:
  - Manufacturing of drugs
  - Creation of model animals that mimic human conditions and,
  - Gene therapy
  - Human growth hormones
  - Follicle-stimulating hormones
  - Human albumin
  - Monoclonal antibodies
  - Antihemophilic factors
  - Vaccines
- **In Research:** Genes and other genetic information from a wide range of organisms can be inserted into bacteria for storage and modification, creating genetically modified bacteria in the process.
- **In Industry:**
  - Transformation of cells in organisms with a gene coding to get a useful protein.
  - Medicines like insulin, human growth hormone, and vaccines, supplements such as tryptophan, aid in the production of food (chymosin in cheese making) and fuels are produced using such techniques.
- **In Agriculture:**
  - Genetically modified crops are produced using genetic engineering in agriculture.
  - Such crops are produced that provide protection from insect pests.
  - It is used or can be used in the creation of fungal and virus-resistant crops.
- **Genetic engineering can be applied to other areas:**
  - Conservation
  - Natural area management
  - Microbial art

Benefits of Genetic Engineering

- The production of genetically modified crops is a boon to agriculture.
- The crops that are drought-resistant, disease-resistant can be grown with it.
- As described earlier, genetic disorders can be treated.
- The diseases such as malaria, dengue can be eliminated by sterilising the mosquitoes using genetic engineering.
- Therapeutic cloning

Challenges of Genetic Engineering

- The production of genetically-engineered entities may result in an adverse manner and produce undesired results which are unforeseen.
- With the introduction of a genetically-engineered entity into one ecosystem for a desirable result, may lead to distortion of the existing biodiversity.
- Genetically-engineered crops can also produce adverse health effects.
- The concept of genetic-engineering is debated for its bioethics where community against it argue over the right of distorting or moulding the nature as per our needs.