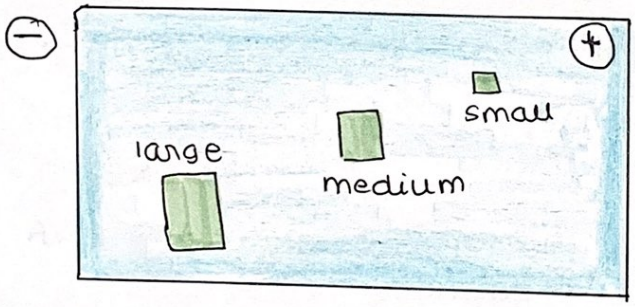
# 3.5 GENETIC MODIFICATION AND BIOTECHNOLOGY

## GEL ELECTROPHORESIS

- It is a technique used to separate charged molecules in an electric field, according to their size and charge.




sample is placed in a block of gel & an electric current is applied.

The samples move through the gel.
Smaller ones move faster and travel further than the other pieces in a given time.

DNA separated on the basis of size

Proteins separated on the basis of charges.

## POLYMERASE CHAIN REACTION

- used to make large number of copies of DNA from a small sample.

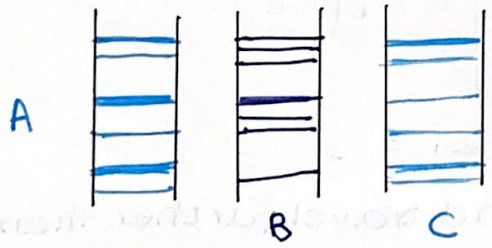
- Each cycle doubles the amount of DNA ($2^n$ - n- no. of cycles.

## Stages of PCR:

- **Denaturing**: DNA sample is heated to separate the 2 strands (95°C)

- **Annealing**: DNA primers attach to the 3' ends of the largest sequence. (55°C)
- **Elongation**: A heat tolerant DNA polymerase binds to the primer and replicates the strand. (72°C)

# DNA PROFILING




It helps compare the DNA sequences.

- used in forensic investigations and paternity testing.

## Stages:

- DNA is obtained from the crime scene / individual
- DNA is amplified using PCR.
- It is split into fragments & separated using Gel electrophoresis.
- This creates a pattern of bands which is the individual's DNA profile.
- These profiles are then compared.

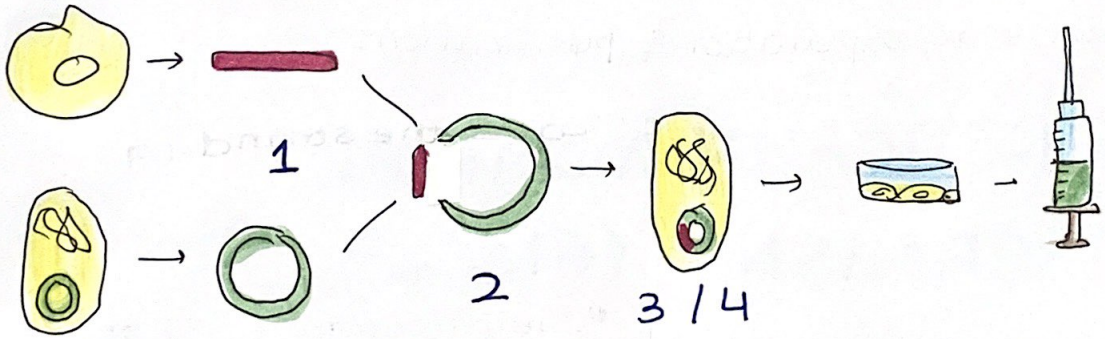
# GENETIC MODIFICATIONS BY GENE TRANSFER

A gene determines a particular trait by encoding for a specific polypeptide in an organism.

Gene modification:

The transfer of genes between species is called gene modification.

The new organism produced is called transgenic.




Process of gene transfer:

1: Isolating the gene & the vector (PCR)

- Vector - DNA molecule that is used as a vehicle to carry the gene into a foreign cell.
- Bacterial plasmids are used as the are able to self. replicate & express.

2: Digestion with Restriction enzymes (restriction endonuclease).

- Both the gene & the vector need to be cut at specific recognition sites by restriction enzymes.
- They generate sticky ends which allows the gene and the vector to merge.

3: Ligation of vector and insert (by DNA ligase).

The plasmid and the cDNA are fused together by DNA ligase to form a recombinant construct.

4: selection and Expression (of the transgenic construct):

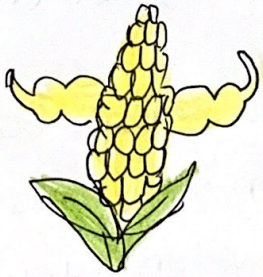
- The recombinant vector is introduced into the host cells by the process of transfection (eukaryotes) or transformation (prokaryotes).
- They grow & multiply in the fermenters & then undergo separation & purification.

# GENETICALLY MODIFIED ORGANISMS (GMOS)

These are used in agriculture to improve the yield.

Genetically modified crops & Human health:

- The nutritional value can be improved.
- Crops that lack allergens or toxins can be produced naturally.
- can be used to produce edible vaccines so that the person eating these can be immune to a particular disease.

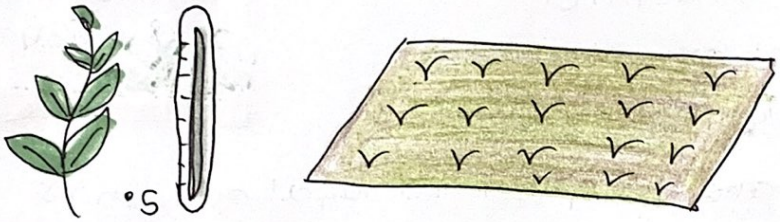



Health risks:

- allergic reactions in humans / livestock
- the genes can get mutated and cause heath issues.

## GM crops and Agriculture :

- Crops that are resistant to drought, cold can be produced. This can help increase the total yield.
- Gene for herbicide resistance can be transferred to the plants. All other plants in the growing plant will get killed.



- Crops that are resistant to diseases can be produced by gene modification.

## GM crops and economics:

- An improved yield can reduce the farming costs.
- Yield can be improved if the crops have:-

→ Better shelf-life

→ Resistance to diseases

→ Genes that help them grow in any environment

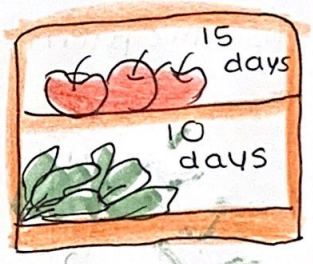
→ Herbicide resistance


↙ unwanted plants

## GM crops and environment:

- Pest resistant crops can be produced so that the use of insecticides can be reduced.
- Shelf-life can be improved which reduces wastage

### Agricultural issues:




- it can be hard to control unwanted plant growth if the plants are herbicide resistant.
- Strains that are adapted to local conditions cannot be developed as farmers are not allowed to re-sow GM seeds.

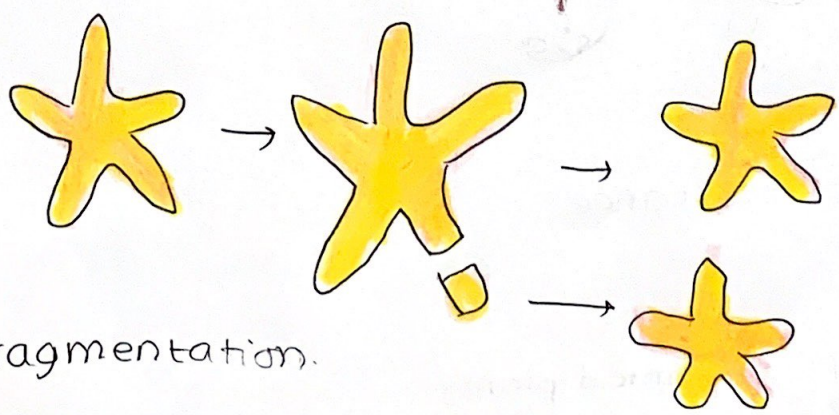
### Environmental issues:

- Non-targeted insects can get affected by the plants that are intended to control pests.
- Herbicide resistance - unwanted weed growth

# NATURAL CLONING

Many species can reproduce asexually & can make natural clones.

### Animal cloning methods:



Fragmentation.

## 1. Binary Fission

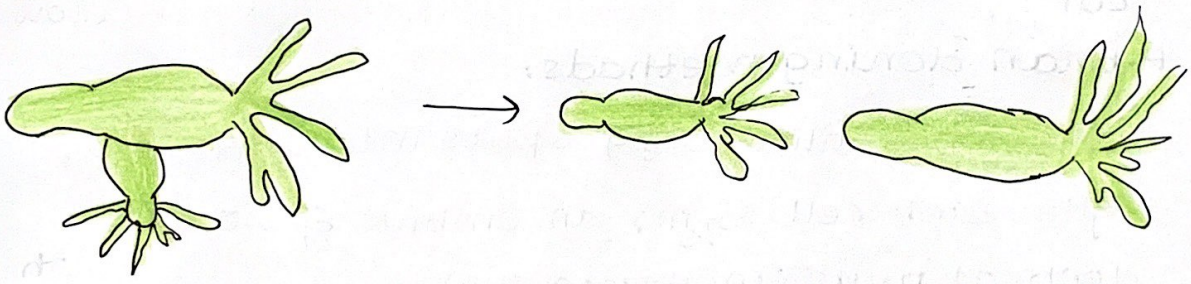
→ The parent organism divides equally into 2 identical daughter organisms.

(Planaria, amoeba etc.)

## 2. Budding

→ Cells split off the parent organism and form a daughter cell that splits off from the parent after maturing.

(Hydra, yeast)



## 3. Fragmentation

→ New organism grows from a separated fragment of the parent organism.

(starfish, annelid worms)

## 4. Parthenogenesis

→ Embroys are formed from unfertilized ova

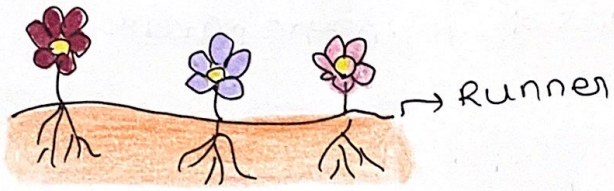
→ The female produces a diploid egg.

(insects, fish, amphibians)

## Plant cloning methods:

- Vegetative propagation -
- small pieces can grow independently.

- Roots and shoots are capable of vegetative propagation.
- Underground stems can also form new genetically identical plants.
- Runners / stolons are horizontal stems that grow roots and can develop into clones.




Human cloning methods:

→ When a fertilized egg splits into 2 identical cells, each cell forms an embryo & creates identical twins (monozygotic).

→ When an unfertized cell splits into 2 and each gets fertilized by a different sperm, non-identical twins are formed. (dizygotic)

100% identical

50% identical

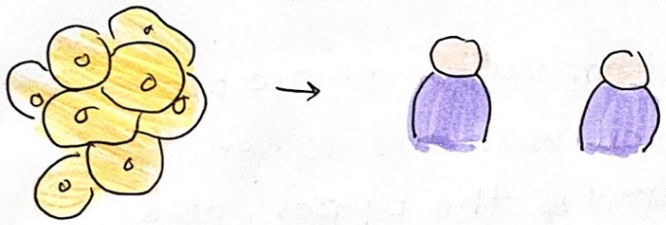
# ARTIFICIAL CLONING

Embryonic cells are able to divide and differenciate into any type of tissue (pluripotent).

If the embryonic cells can be separated in the lab, each group of cells will formed cloned organisms.

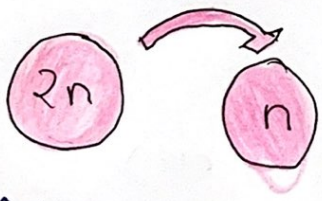
→ This separation needs to happen around the 8 cell stage (morula).

These cells can then be implanted in the mother's womb so that they develop into genetically identical clones.




Second method of cloning is somatic cell nuclear transfer. (SCNT).

→ The diploid nucleus from an adult donor replaces the haploid nucleus of an unfertilised egg.




Advantage:

The traits of the clone are known beforehand & are genetically identical to the donor.

It can be used for 2 purposes:

- Reproductive cloning
- Therapeutic cloning

# STEM CUTTINGS

- It is a separated portion of the plant stem that can regrow on its own to form a new clone via vegetative propagation.

**Nodes** - leaves, branch, aerial roots grow from this.

**Internodes** - spaces between the nodes.


The stem cuttings are placed in the soil with the lower nodes covered & the upper nodes exposed.

## Factors affecting stem cutting:

- cutting position
- length of cutting
- growth medium (pot, compost, open)
- use & concentration of growth hormones
- temperature
- availability of water
- environmental conditions (pH, light etc.)