BIOTECHNOLOGY

I. Selective Breeding

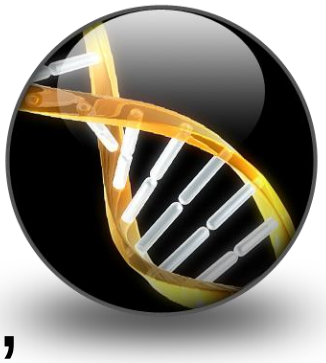
1.) **Selective breeding** = The process by which desired traits of certain plants and animals are selected and passed on to their future generations.

- Breed only those plants or animals with desirable traits

2.) People have been using selective breeding for 1000's of years with farm crops and domesticated animals.

II. Human Genome Project (HGP)

1.) HGP = **Map** of all 30,000 genes on the 46 human chromosomes (1988-2003)



- Information has led to many advances in the fields of medicine, agriculture, bio-engineering

2.) An organism's **genome** is the total DNA in the nucleus of each cell

III. GENETIC ENGINEERING

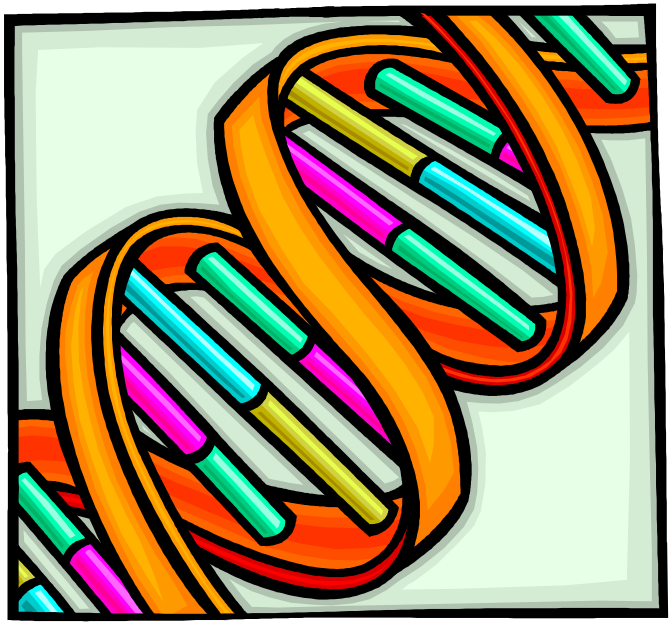
1.) Biotechnology refers to technology used to **manipulate** DNA.

2.) The procedures are often referred to as **genetic engineering**.

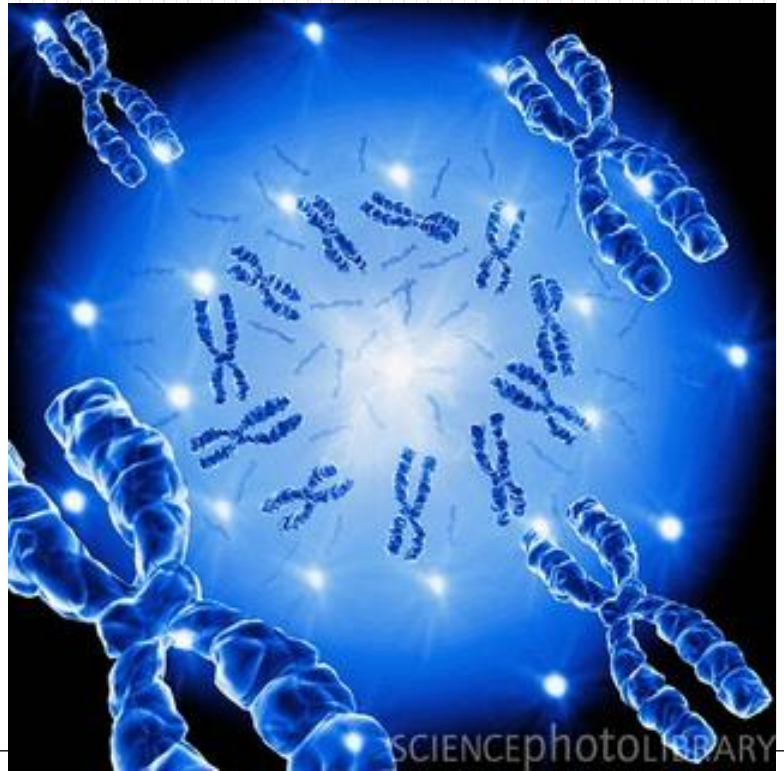
III. GENETIC ENGINEERING

3.) **DNA** is the genetic material of all living organisms.

- All organisms use the **same** genetic code (A, T, C, G).



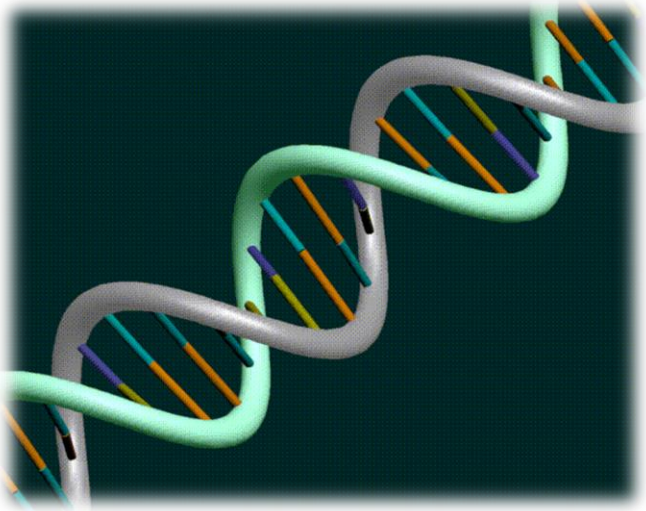
CREATING RECOMBINANT DNA



IV. RECOMBINANT DNA

1.) **Recombinant DNA** refers to the DNA from the two DIFFERENT organisms.

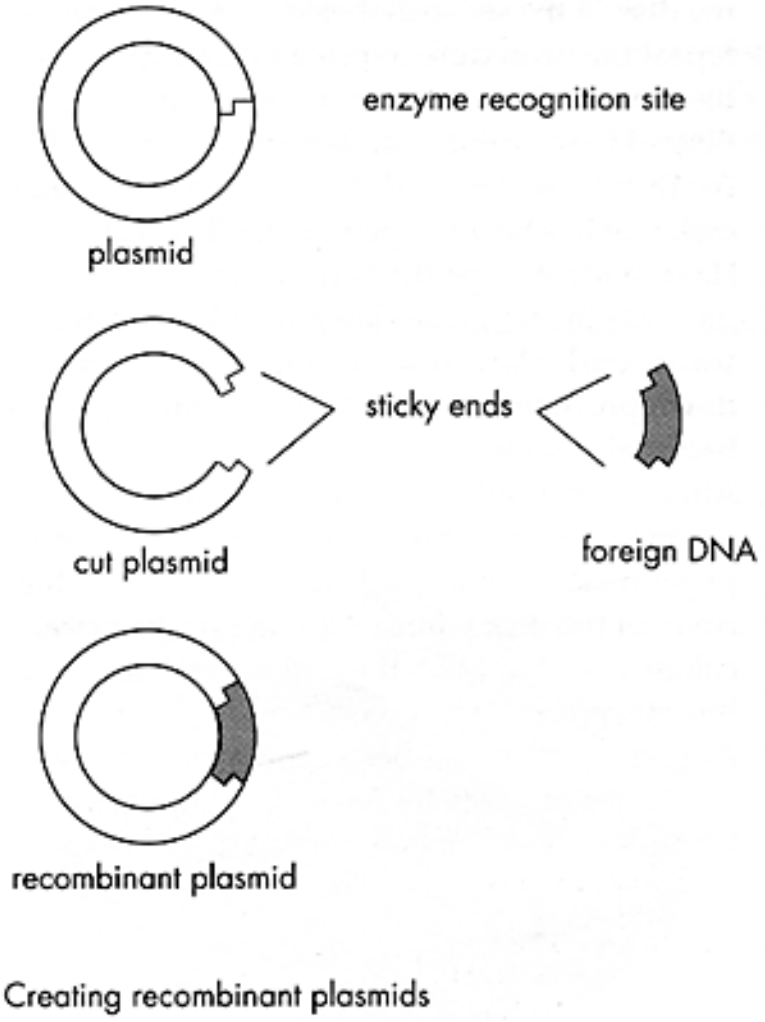
- Can be used for creating transgenic organisms, gene therapy, and cloning.



IV. RECOMBINANT DNA

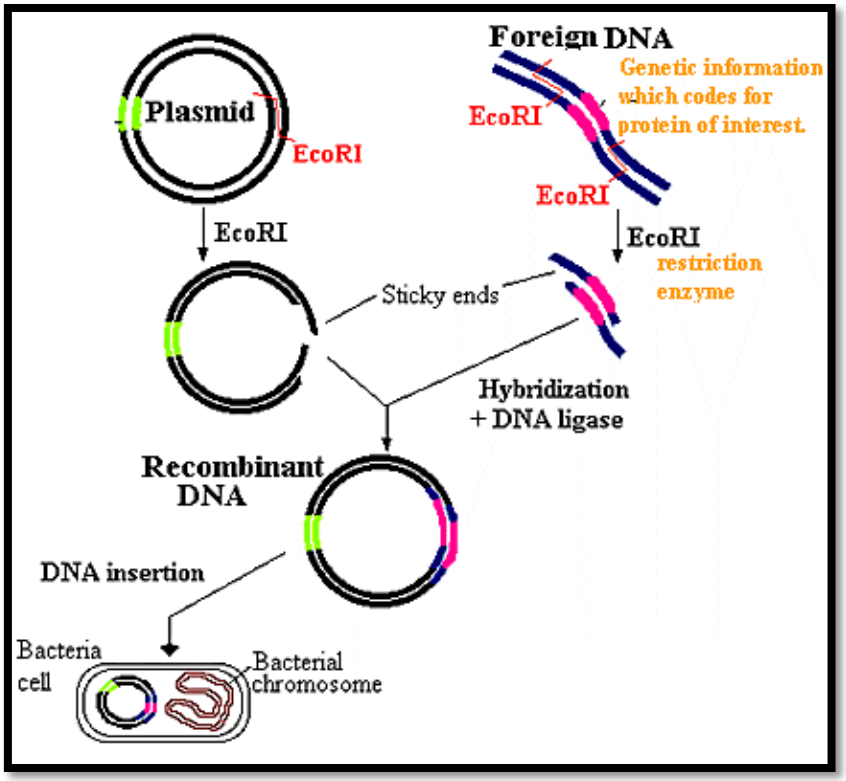
2.) Recombinant DNA technology was first used in the 1970's with bacteria.

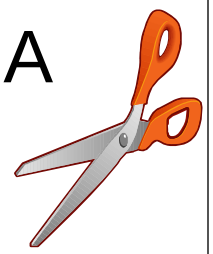
3.) A **plasmid** is small ring of DNA in a bacterium



Creating recombinant plasmids

4.) Making Recombinant Bacteria



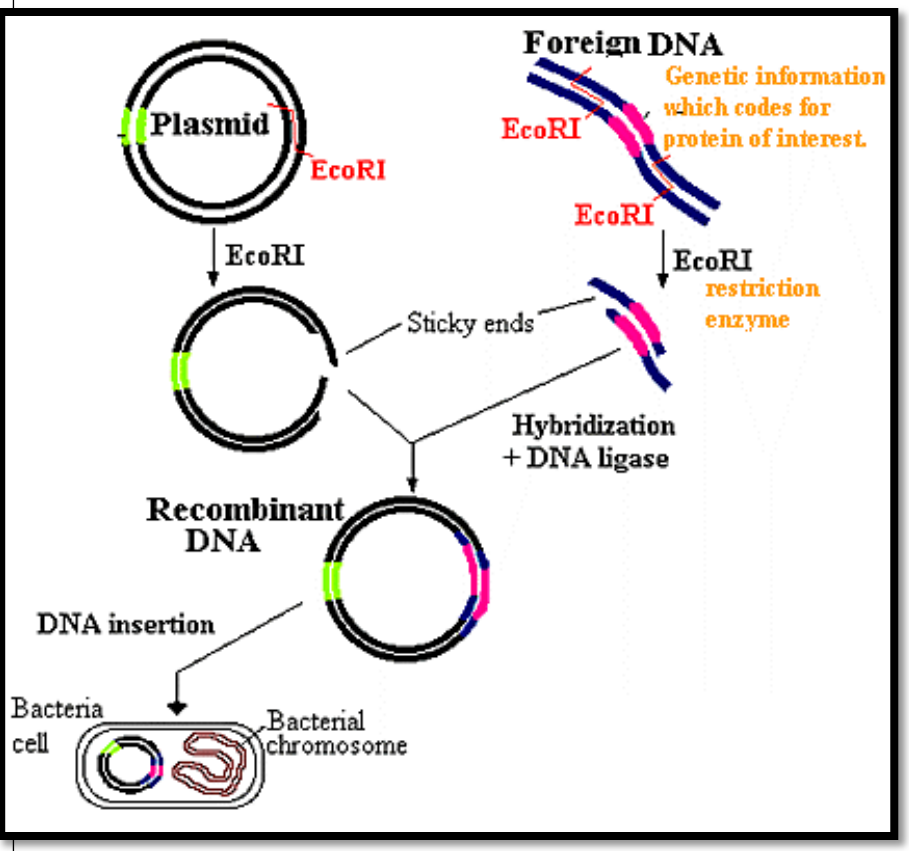


a.) Remove bacterial DNA (plasmid).

b.) Cut the Bacterial DNA with "**restriction enzymes** (RE)".

- Restriction enzymes were discovered in **bacteria.**
  - Bacteria use them as a defense mechanism to cut up the **DNA** of viruses or other bacteria

4.) Making Recombinant Bacteria

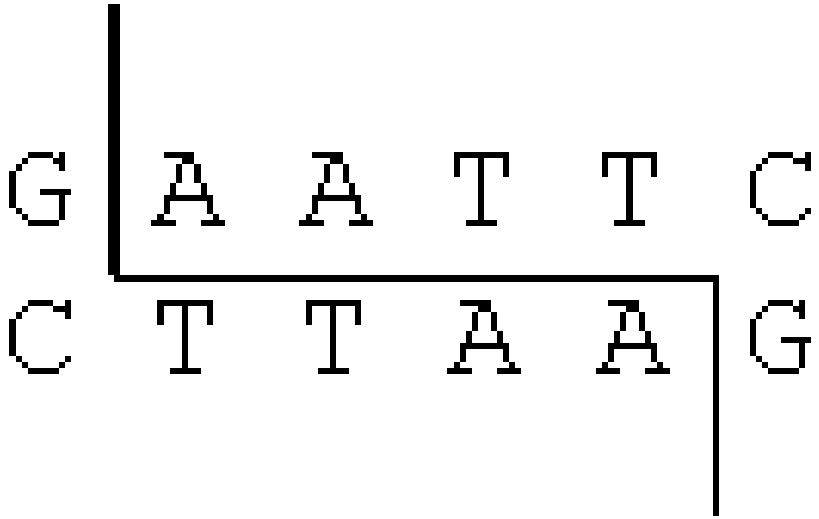


- Hundreds of different **<u>restriction enzymes</u>** have been isolated

- Each restriction enzyme or RE cuts DNA at a **<u>SPECIFIC</u>** base sequence.

4.) MakingRecombinant Bacteria

- For example, EcoRI always cuts DNA at GAATTC as indicated below



The sequence GAATTC appear three time in the below strand of DNA, so it is cut into four pieces.

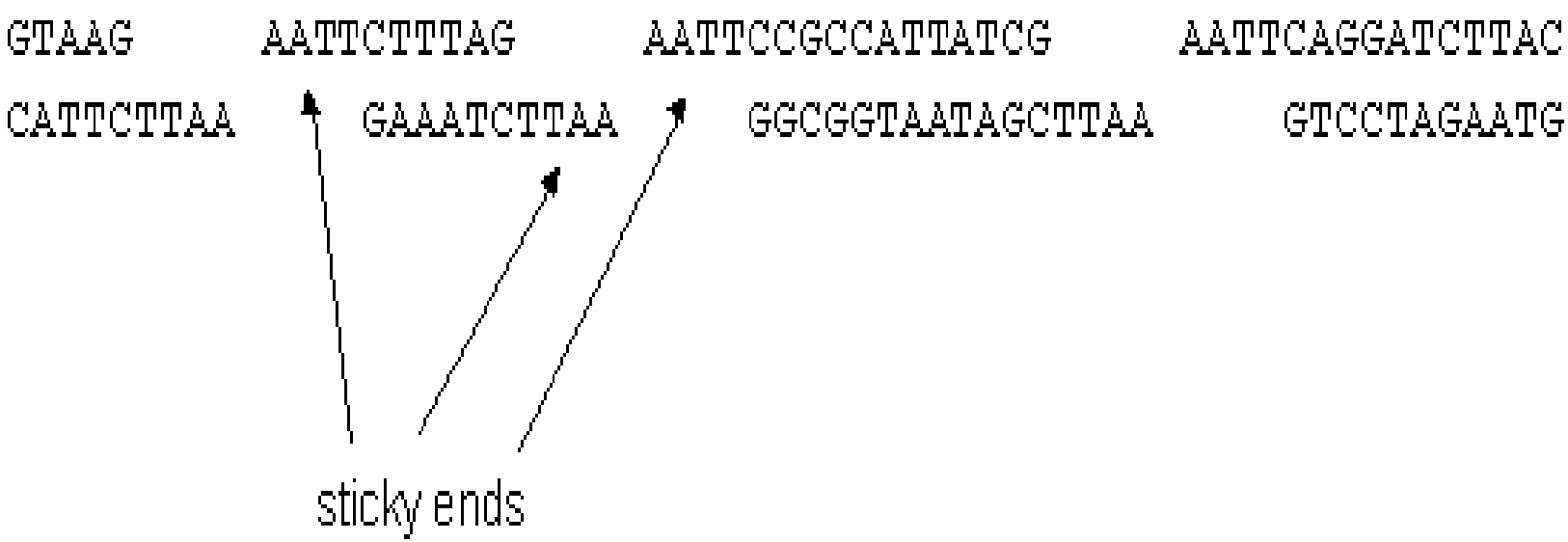
GTAAGAATTCTTTAGAATTCCGCCATTATCGAATTCAGGATCTTAC

CATTCTTAAGAAATCTTAAGGCGGTAATAGCTTAAGTCCTAGAATG

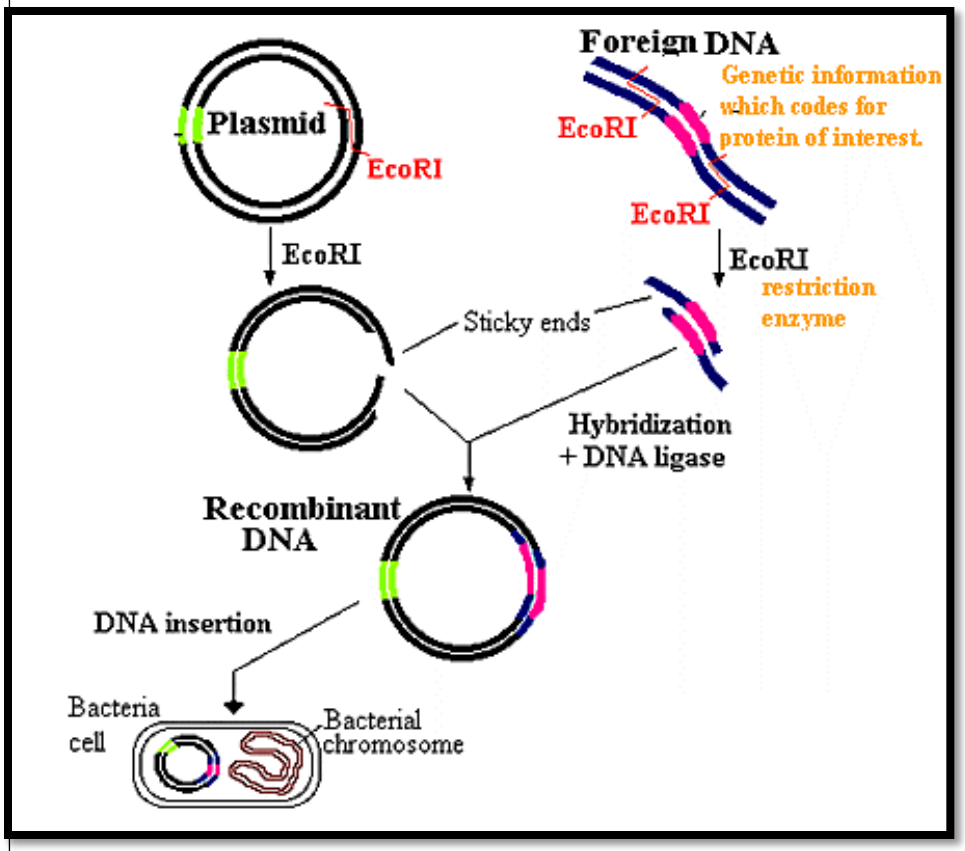
GTAAG AATTCTTTAG AATTCCGCCATTATCG AATTCAGGATCTTAC

CATTCTTAA GAAATCTTAA GGCGGTAATAGCTTAA GTCCTAGAATG

- Fragments of DNA that has been cut with restriction enzymes have unpaired nucleotides at the ends called **sticky ends**. Sticky ends have complimentary bases, so they **could rejoin**.

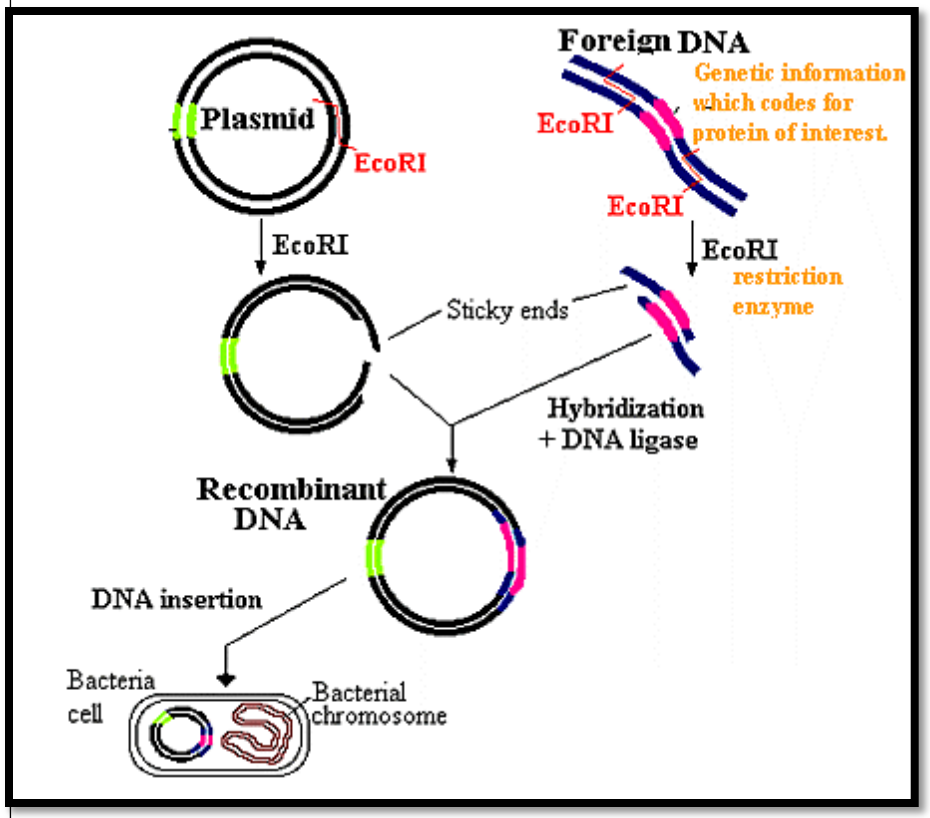


4.) Making Recombinant Bacteria



c.) Cut the gene of interest from the organism's DNA with **same** "restriction enzyme" (RE).

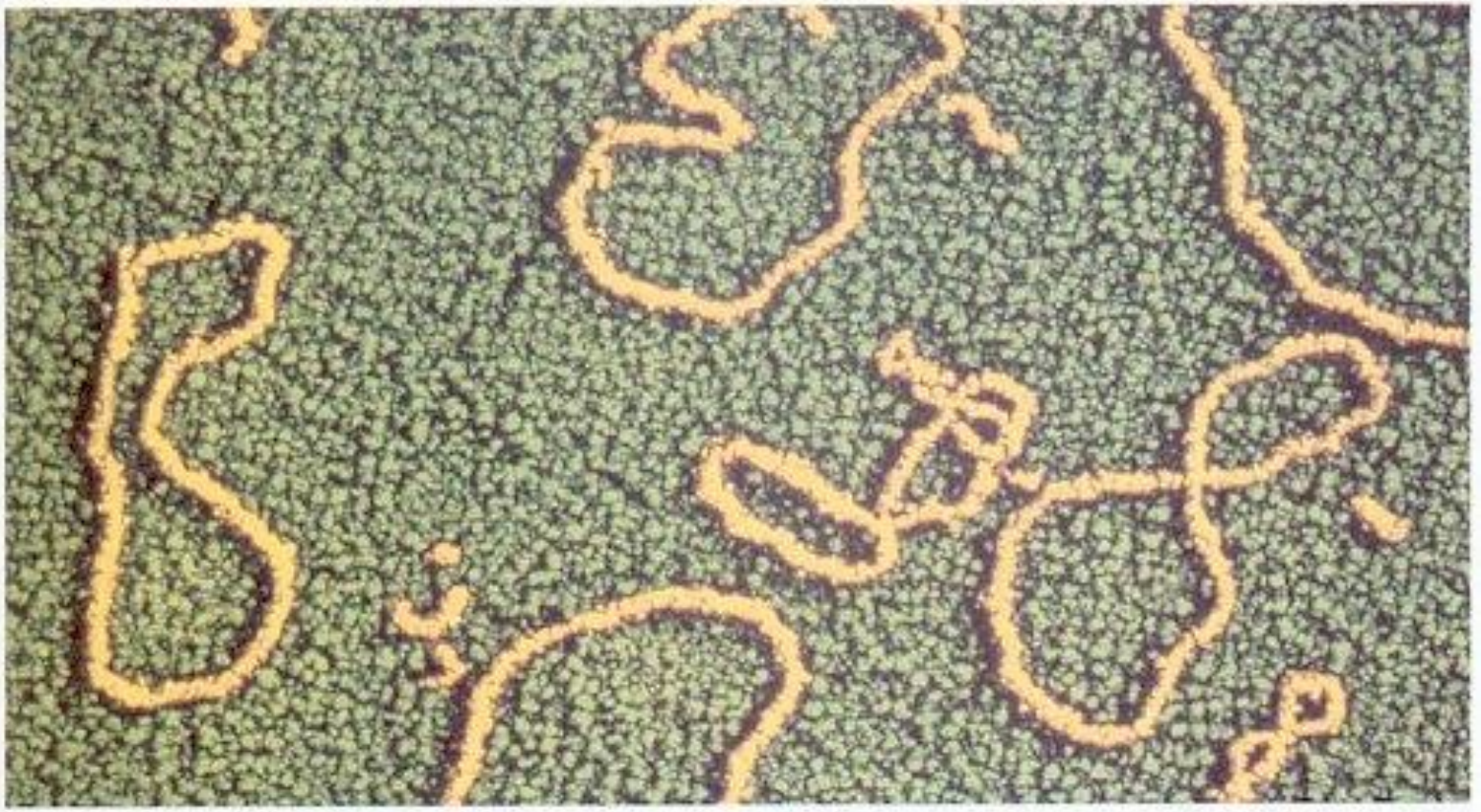
4.) Making Recombinant Bacteria



d.) Combine the "sticky ends" of the two DNA pieces together with **DNA ligase** (enzyme) – also known as **gene splicing**.

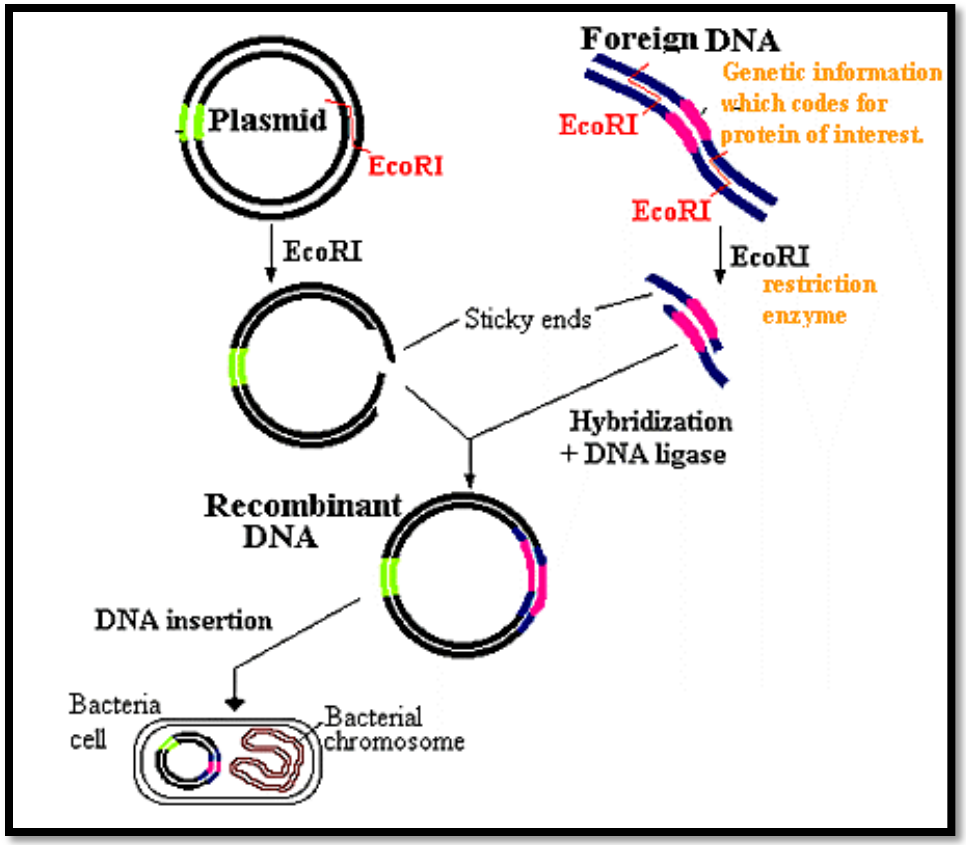
- This creates a **vector** = a DNA molecule used to carry a gene of interest from one organism to another.

- **<u>Plasmids</u>** & **<u>viruses</u>** are the most commonly used vectors



Plasmids are small circles of DNA found naturally in the cells of some organisms. A plasmid can replicate itself as well as any other DNA inserted into it. For this reason, plasmids make excellent cloning vectors—structures that carry DNA from cells of one species into the cells of another.

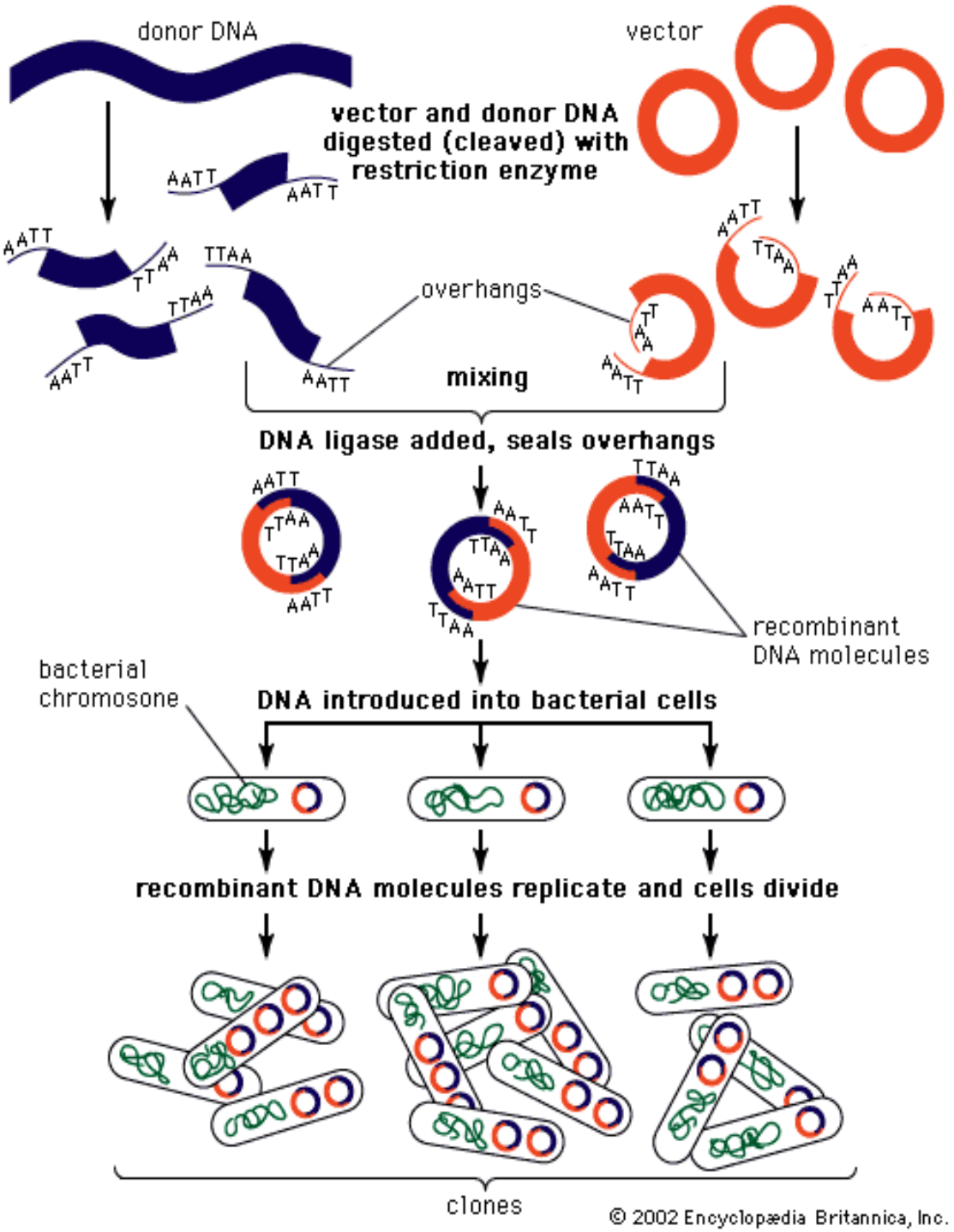
4.) Making Recombinant Bacteria



e.) Insert vector into bacteria.

f.) The bacteria can now **reproduce** the recombinant DNA.

g.) The foreign genes will be **expressed** in the bacteria.


donor DNA
vector
vector and donor DNA digested (cleaved) with restriction enzyme
overhangs
mixing
DNA ligase added, seals overhangs
recombinant DNA molecules
bacterial chromosone
DNA introduced into bacterial cells
recombinant DNA molecules replicate and cells divide
clones
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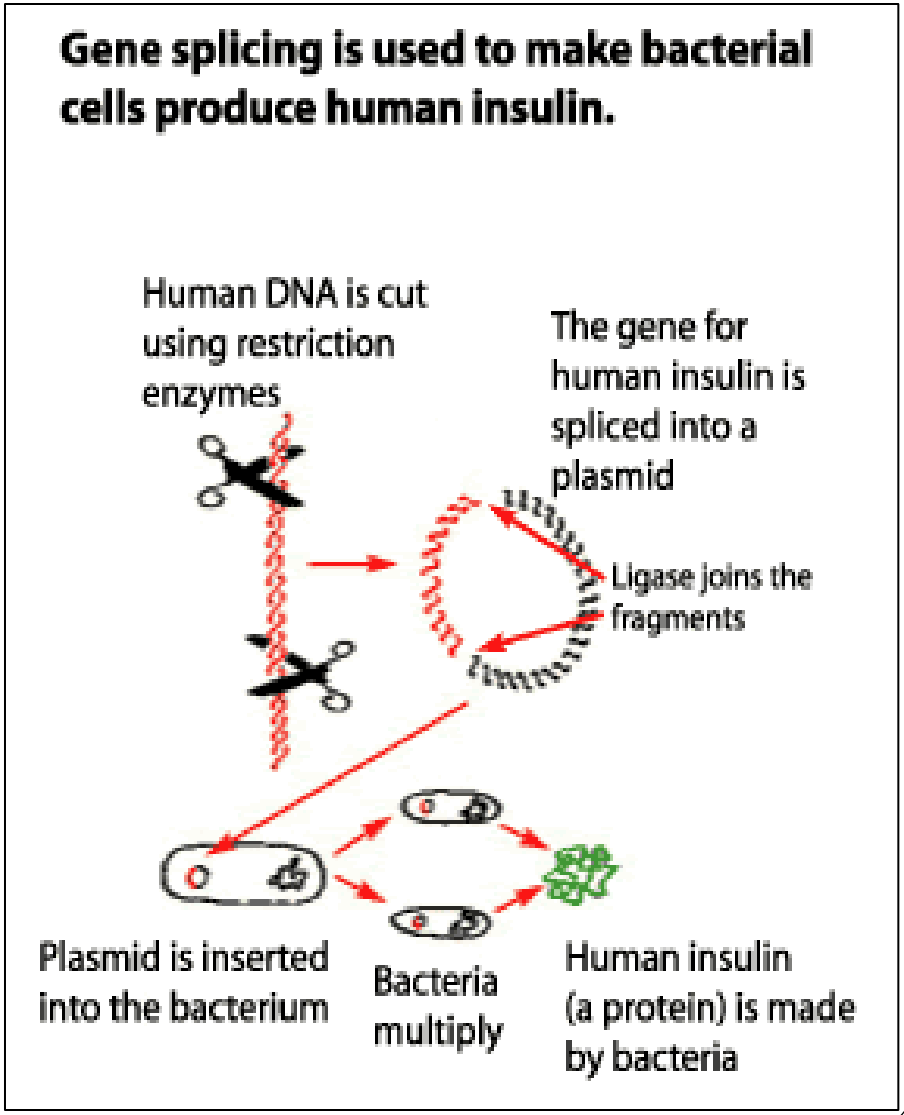
5.) Benefits of Recombinant Bacteria

- Bacteria can make human **insulin** or **human growth hormone**.

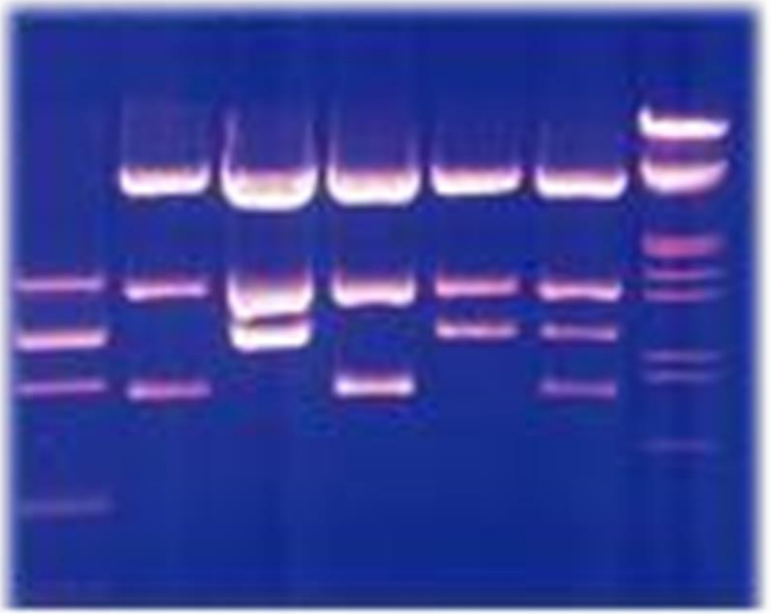


5.) Benefits of Recombinant Bacteria

- Bacteria can be engineered to “eat” **oil** spills.

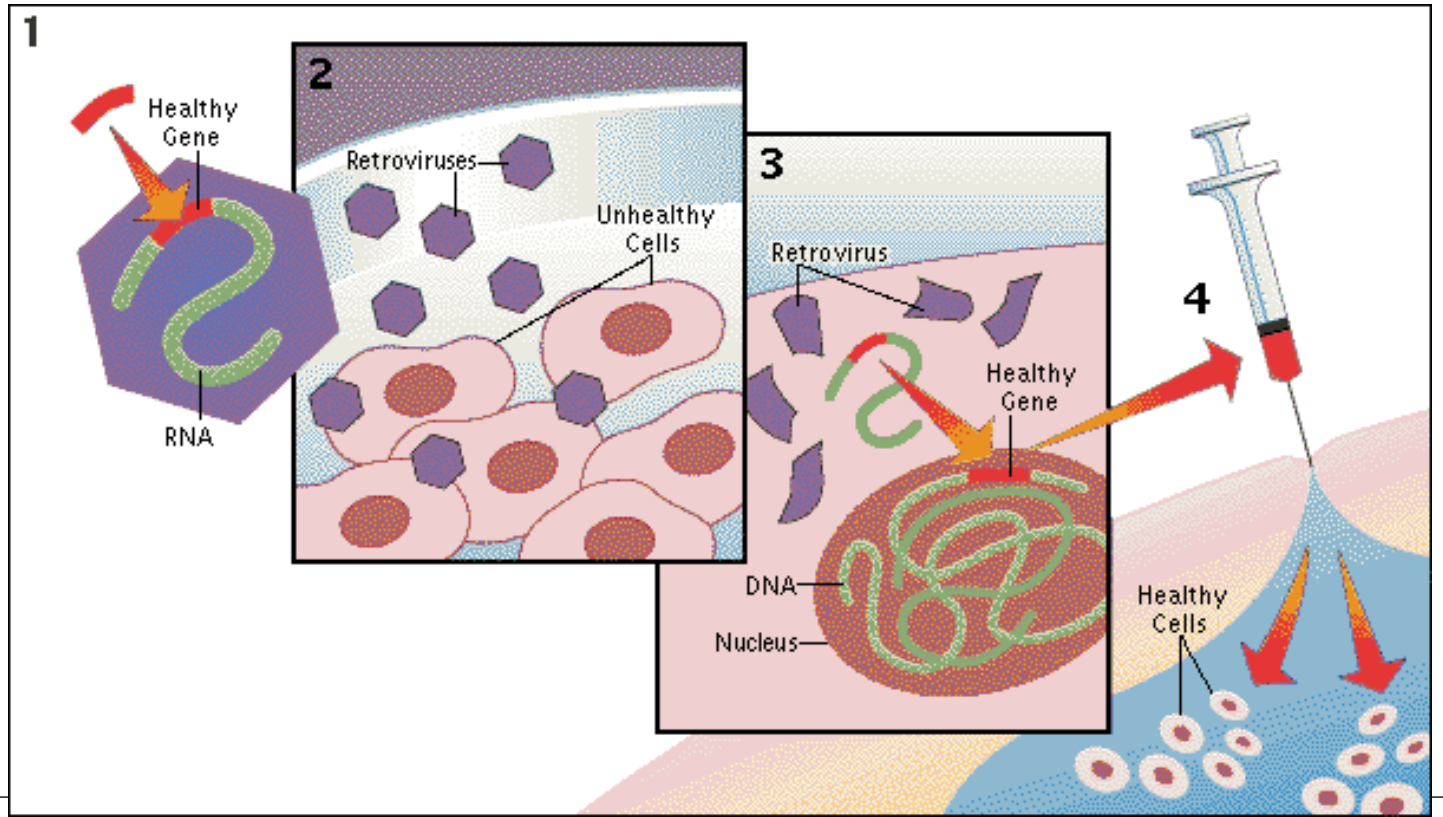
V. GENETIC ENGINEERING: What Can We Do With Genes?

1. DNA fingerprinting - Recombinant DNA techniques are used in **DNA fingerprinting**



V. GENETIC ENGINEERING: What Can We Do With Genes?

2. **Gene therapy:** A "normal" gene is inserted into the genome to replace an "abnormal," disease-causing gene.



Gene Therapy

- In the future, may be used treat a disorder by inserting a gene into a patient's cells instead of using drugs or surgery.

- Types of gene therapy:
  - **Replacing** a mutated gene that causes disease with a healthy copy of the gene
  - **Inactivating**, or "knocking out," a mutated gene that is functioning improperly.
  - Introducing a new gene into the body to help fight a disease.

Gene Therapy

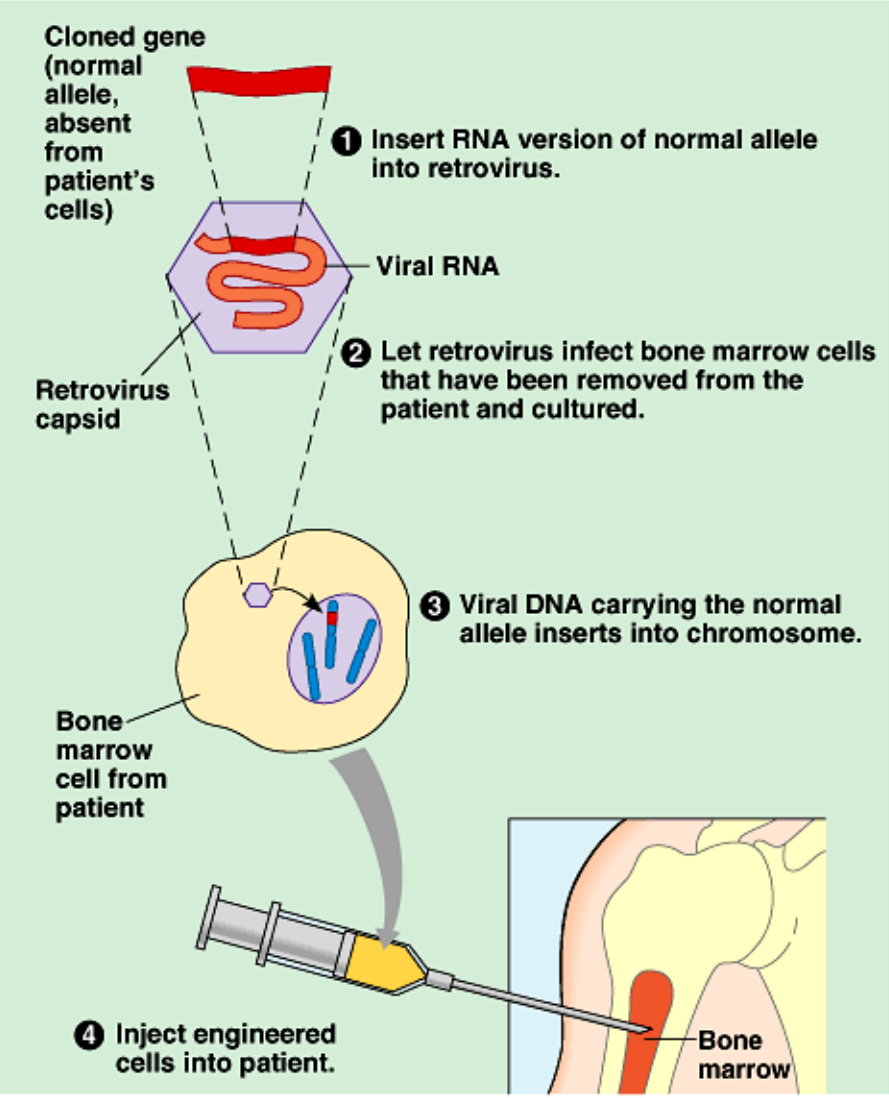
- Currently, the only way for you to receive gene therapy is to participate in a clinical trial.
  - **Clinical trials** are research studies that help doctors determine whether a gene therapy approach is safe for people.

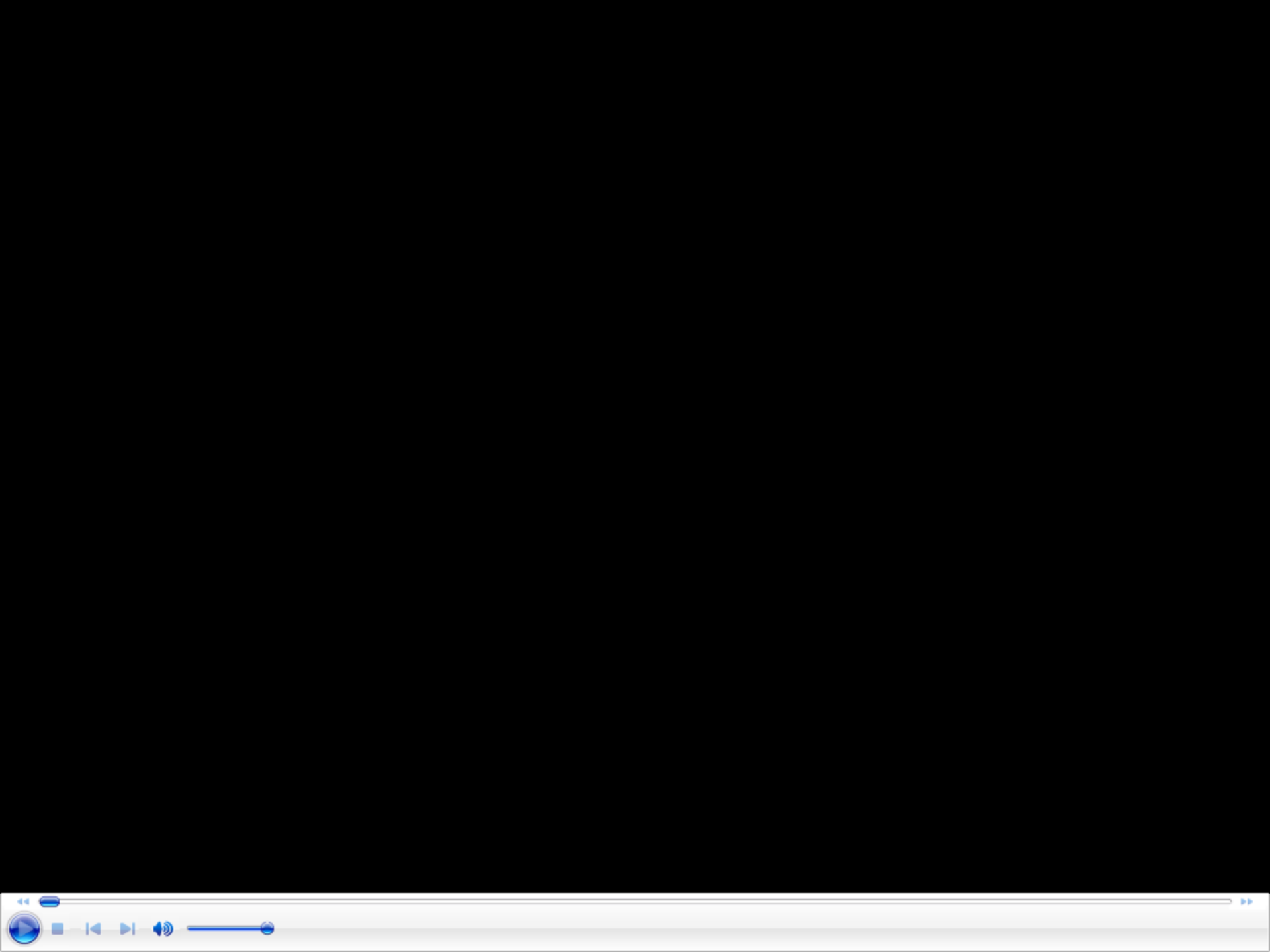
Gene Therapy

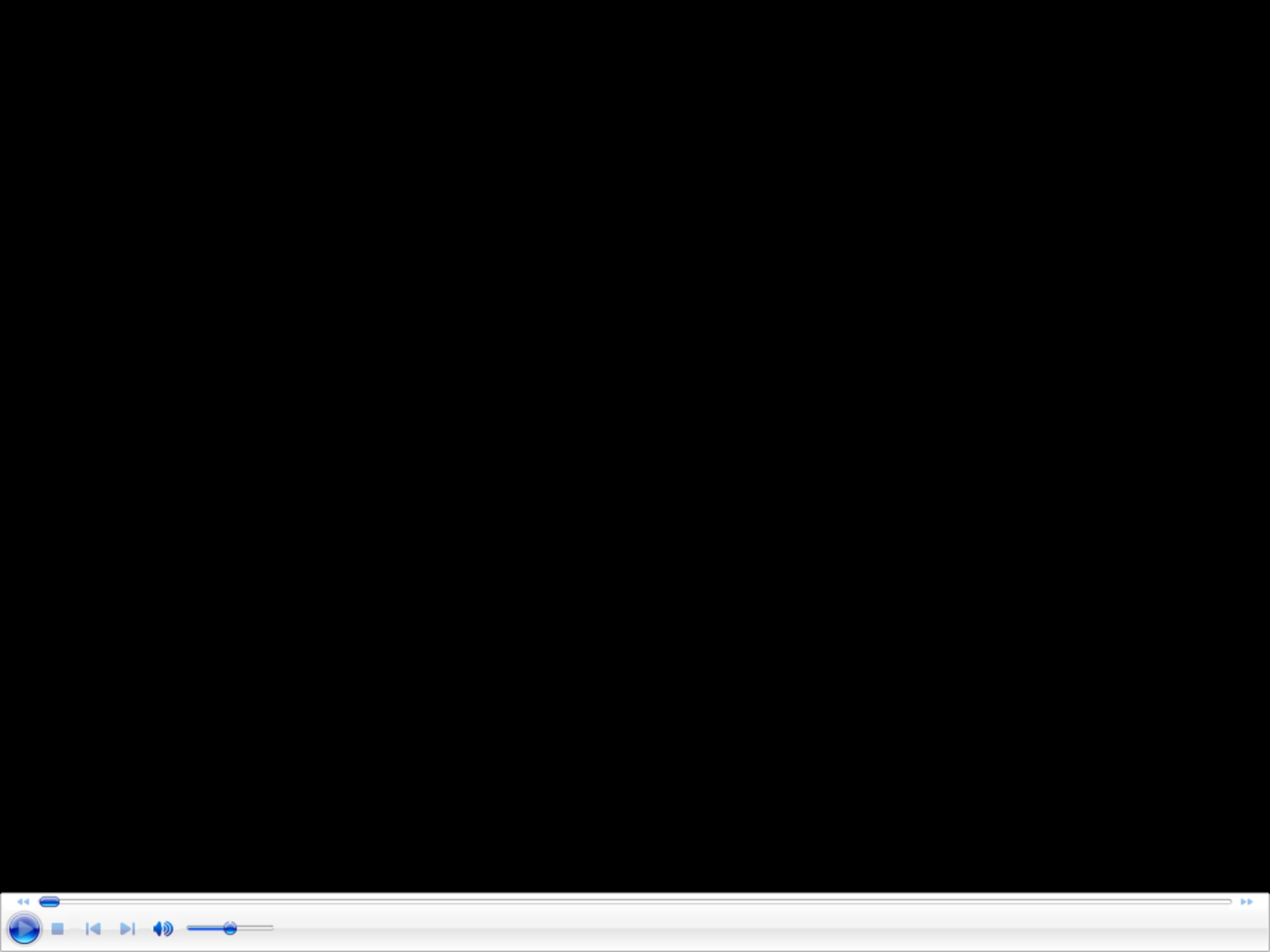
- The Food and Drug Administration (FDA) has **NOT** yet approved any human gene therapy product for **sale**.

APPLICATIONS

One type of gene therapy procedure







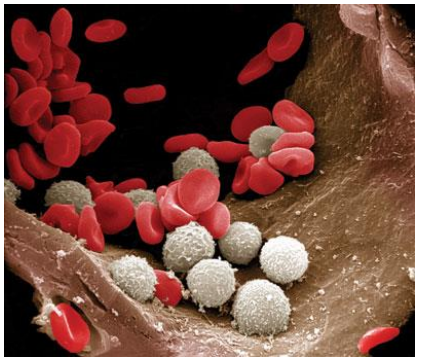
- Making of Insulin
  http://www.youtube.com/watch?v=AEINuCL-5wc&feature=related
- Gene Therapy

http://www.youtube.com/watch?v=EfXK50Bxod8&feature=PlayList&p=75527107C0AFBA9F&playnext=1&playnext_from=PL&index=43

- Blindness
  http://www.youtube.com/watch?v=NmftOETlyyg&feature=PlayList&p=75527107C0AFBA9F&playnext=1&playnext_from=PL&index=44

Risk Factors of Gene Therapy

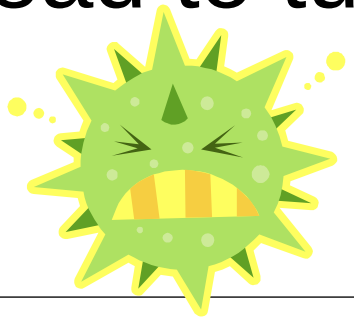
- **Unwanted immune system reaction.** Your body's immune system may see the newly introduced viruses as intruders and attack them (inflammation & organ failure).



- **Targeting the wrong cells.** Viruses could infect healthy cells and cause other illnesses, including cancer.

Risk Factors of Gene Therapy

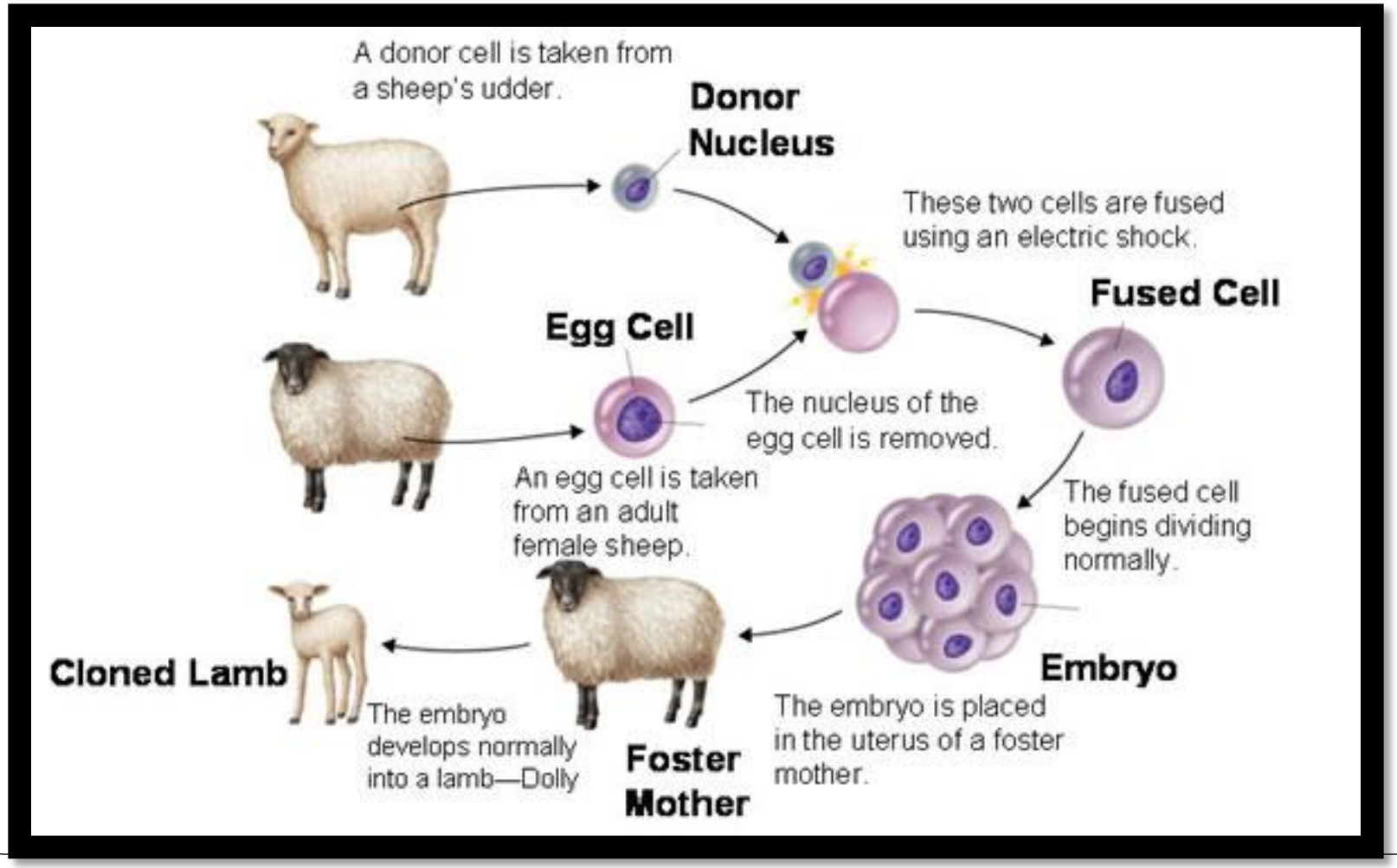
- **Infection caused by the virus.** Viruses may recover their original ability to cause disease.
- **Possibility of causing a tumor.** If the new genes get inserted in the wrong spot in your DNA, there is a chance that the insertion might lead to tumor formation.

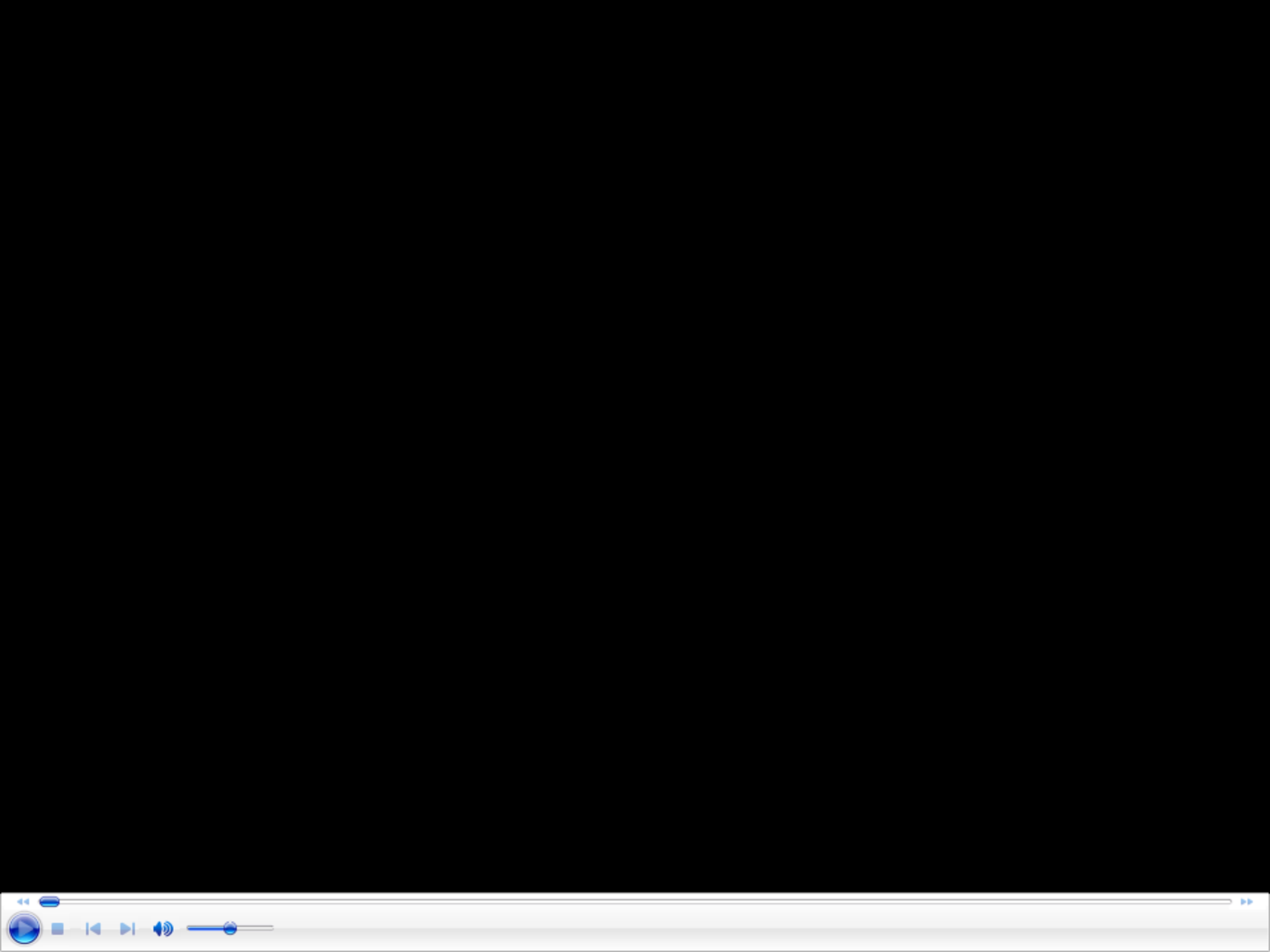


V. GENETIC ENGINEERING: What Can We Do With Genes?

3. **Gene cloning:**
   Creating genetically IDENTICAL copies

- Ex: **Dolly** (1996-2003)- it took 276 attempts before successful





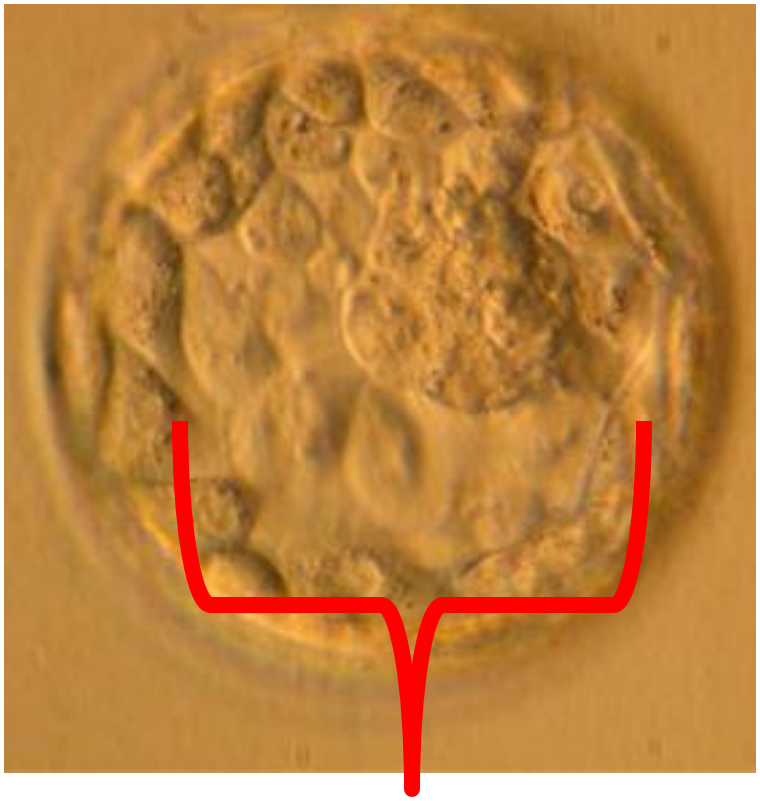
V. GENETIC ENGINEERING: What Can We Do With Genes?

4. **Stem cells** can be used to generate virtually any type of specialized cell in the human body.

- The goal of this process is to harvest stem cells that can be used to study human development and to treat disease.

V. GENETIC ENGINEERING: What Can We Do With Genes?

- Stem cells are extracted from the egg after it has divided for 5 days.



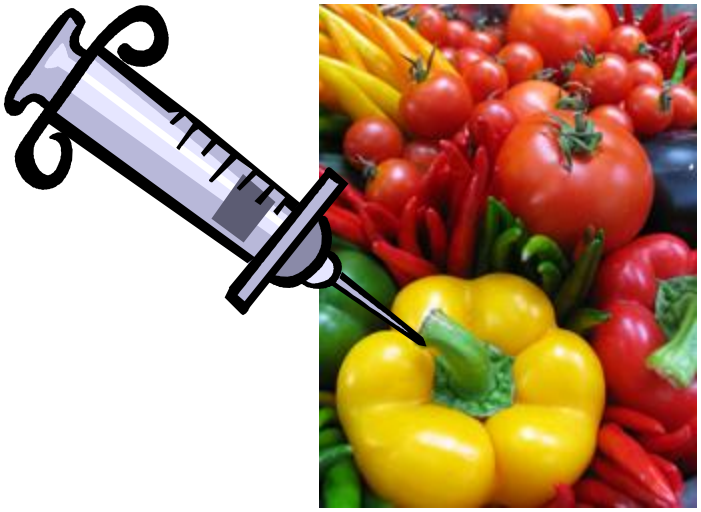
V. GENETIC ENGINEERING: What Can We Do With Genes?

- The extraction process destroys the embryo, which raises a variety of **ethical concerns**.

- Researchers hope that stem cells can be a treatment for heart disease, Alzheimer's, cancer, and other diseases.

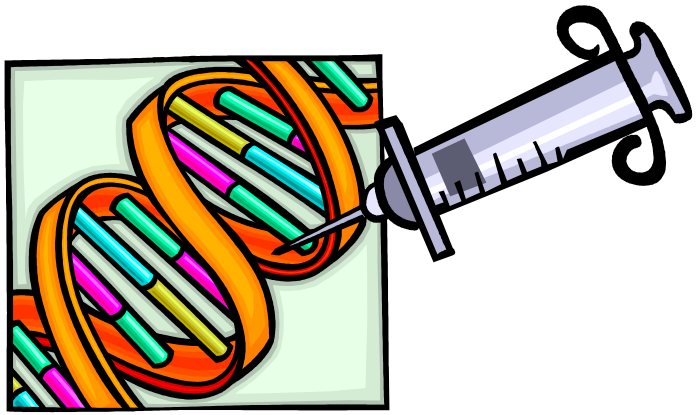
V. GENETIC ENGINEERING: What Can We Do With Genes?

5. **Genetically Modified Organisms**
(GMO) = are organisms with artificially altered DNA. They can be created by:



Genetically Modified Organisms

- **Adding** a foreign gene: Organisms that are altered in this way are known as transgenic organisms.
- **Altering** the base sequence of an existing gene: (Gene therapy)



Genetically Modified Organisms

- **Deleting** or "Turning off" an existing gene: (so they don't produce their protein).
  - Ex: deactivating the gene responsible for the ripening of tomatoes. This new gene can then be inserted into tomato DNA to give them a longer shelf life.

Genetically Modified Organisms

- GMO are also called, **transgenic organisms:** organisms that contain functional recombinant DNA

GloFish: World's First Transgenic Pet

Genes from jellyfish and coral give the GloFish their vivid colors: **starfire red**, **electric green**, and **sunburst orange**.

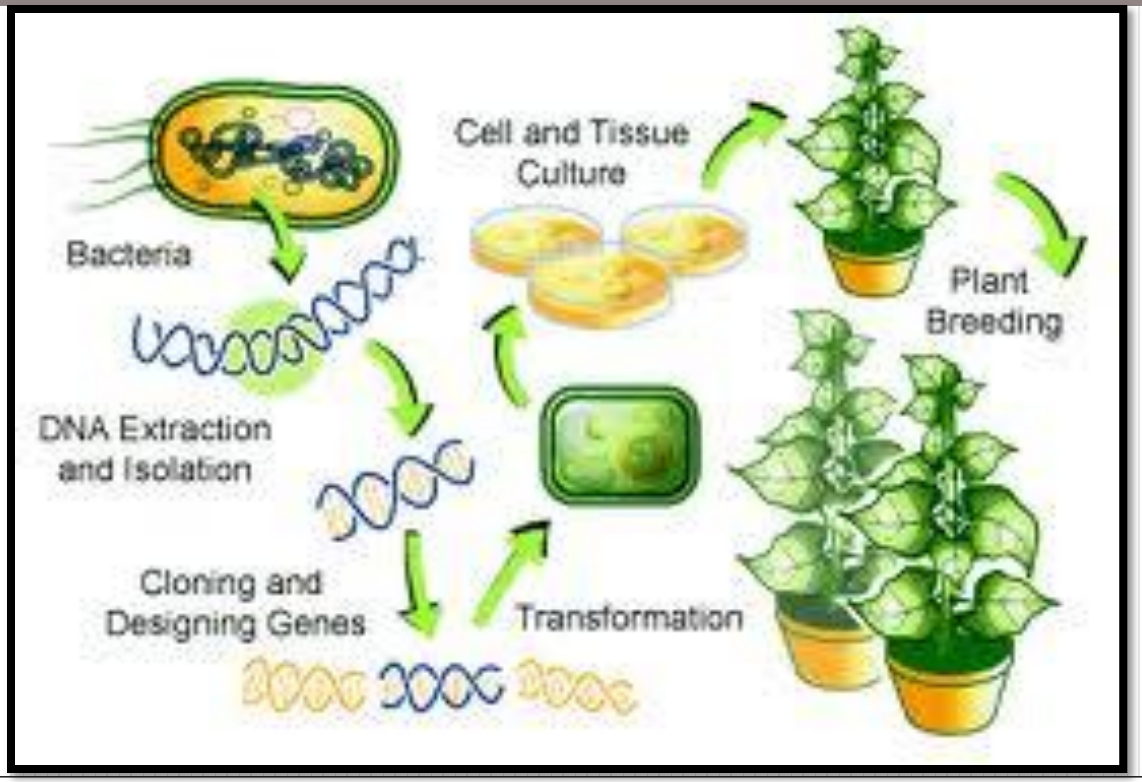
Genetically Modified Organisms

A.) Transgenic PLANTS

- Disease-resistant and insect-resistant crops

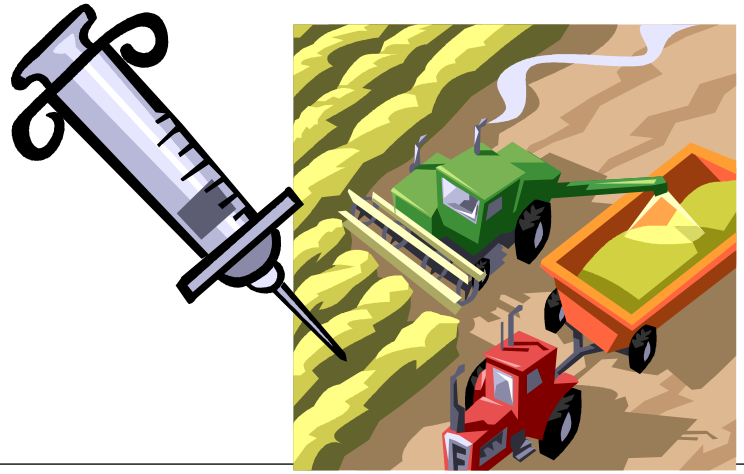
- Hardier fruit
- 70-75% of food in supermarket is genetically modified.

EXAMPLES OF TRANSGENIC PLANTS



A.) Transgenic Plants:

- **Round-up ready corn/soybeans-** Incorporating bacterial genes for resistance to herbicides, so a crop plant is not killed by weed killer (herbicide).
  - Round-up (an herbicide) kills weeds
  - Farmers can spray crops with Round-up and it will kill the weeds and not the corn/soybeans.



A.) Transgenic Plants:

- Incorporating bacterial genes, which produce their own **insecticide** into corn plants.
  - **Bt corn** contains a gene from the bacterium *Bacillus thuringiensis.*
  - The "Bt" gene expresses a protein that is toxic to corn-boring insects but is harmless to birds, fish, and mammals (including humans).

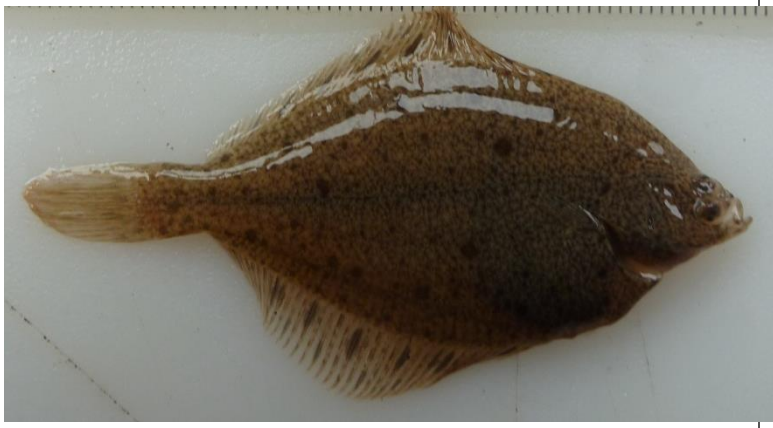
  - Herbivorous insects are thus prevented from eating such plants.

A.) Transgenic Plants:

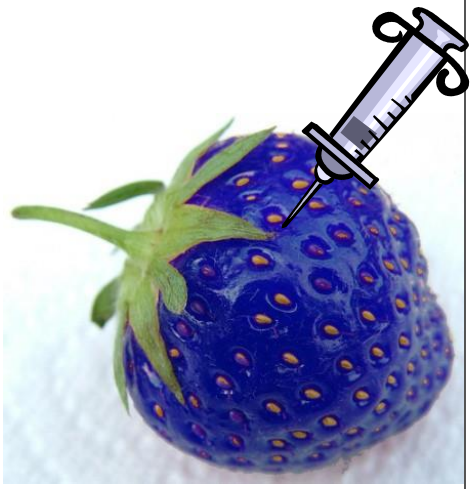
- **B.t. cotton** – *Bacillus thuringiensis* bacteria make a toxin against insects – natural insecticide

A.)Transgenic Plants

- **Frost-free strawberry-** The Arctic Flounder Fish produces an anti-freeze that allows it to protect himself in freezing waters.



- Anti-freeze gene was spliced into a strawberry's genome.
  - Strawberry is blue, doesn't turn to mush or degrade after being placed in the freezer.



A.) Transgenic Plants

- **Golden rice** - two daffodil genes and a bacterial gene spliced into the rice genome to produce more b-carotene, precursor to **Vitamin A**
  - Still not available due to regulations

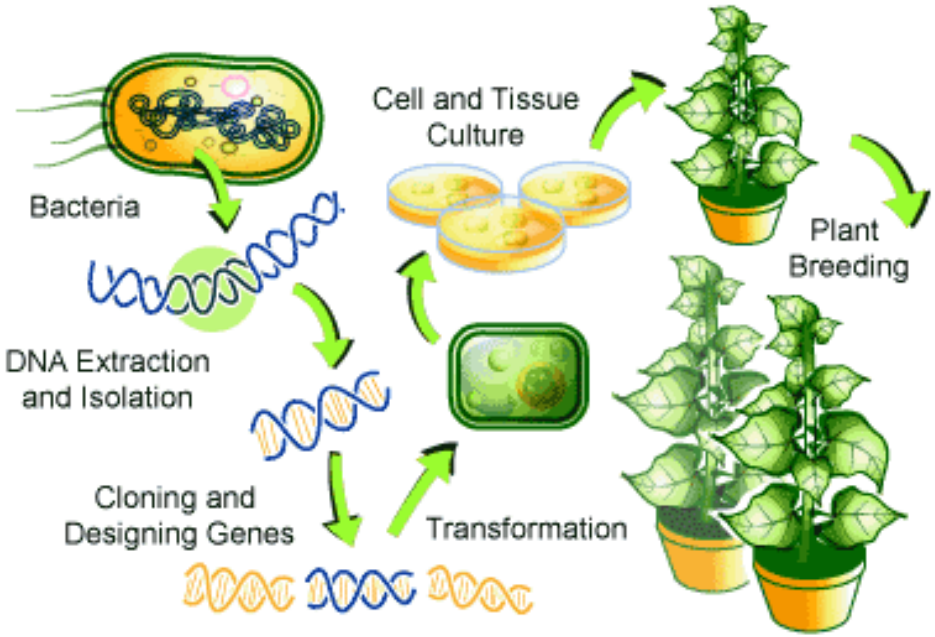
A.) Transgenic Plants:

- **Banana Vaccine**: bananas that contain a vaccine for hepatitis B and cholera.
  - When an altered form of a virus is injected into a banana sapling, the virus' genetic material quickly becomes a permanent part of the plant's cells.
  - Bananas provide an easy means for delivering a vaccine (especially to children) without the need for needles.

A.) Transgenic Plants:

- **Venomous Cabbage** -These genetically modified cabbages would produce scorpion poison that kills caterpillars when they bite leaves — but the toxin is modified so it isn't harmful to humans.

How to Create a Genetically Modified Plant:



a) Create recombinant bacteria with desired gene.

b) Allow the bacteria to “infect" the plant cells.

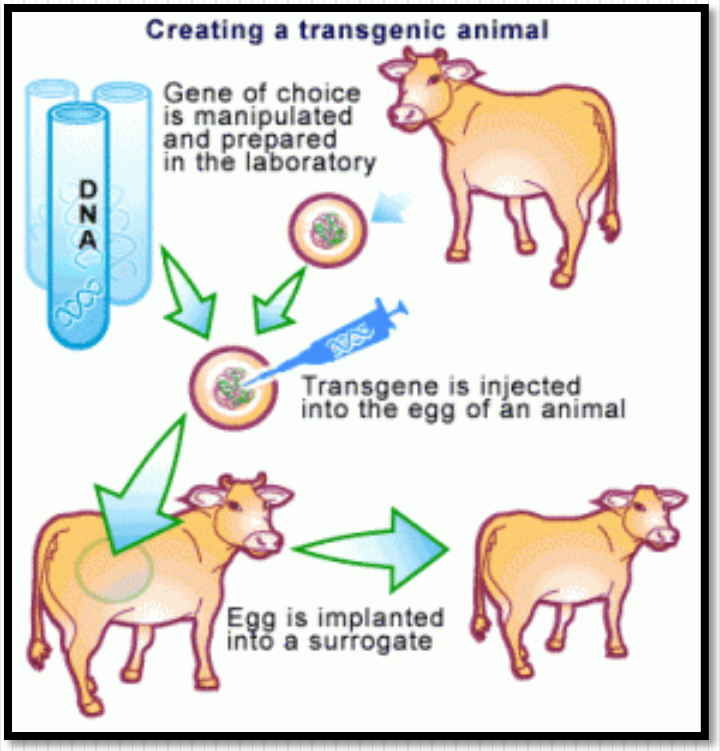
c) Desired gene is inserted into plant chromosomes.

Genetically Modified Organisms

B.) TRANSGENIC ANIMALS

- Mice – used to study human immune system
- Chickens – more resistant to infections
- Cows – increase milk supply and leaner meat
- Goats, sheep and pigs – produce human proteins in their milk

EXAMPLES OF TRANSGENIC ANIMALS



B.) Transgenic Animals:

- **Bovine growth hormone** – increases milk production in cow by 10%

B.) Transgenic Animals:

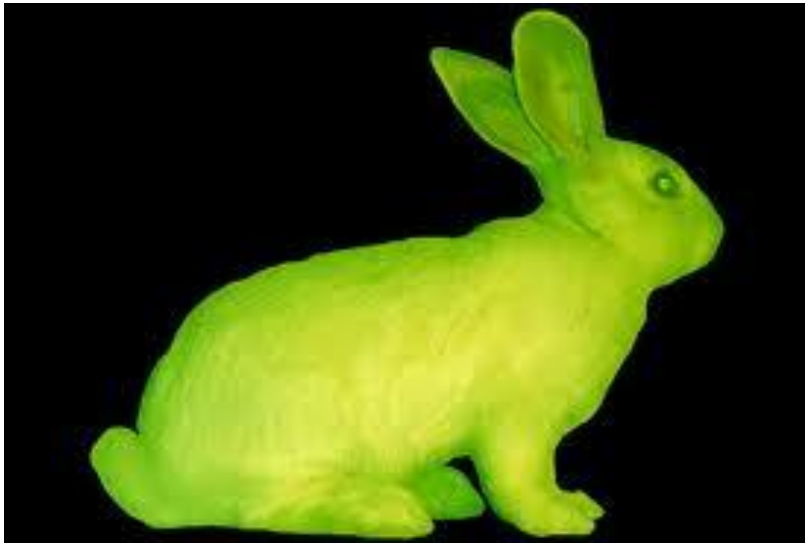
- **Less-flatulent cows –**
  - Methane is a major contributor to the greenhouse effect, so scientists have been working to genetically engineer a cow that produces 25% less methane.

B.) Transgenic Animals:

- Goats - produce milk containing high levels of a **human protein** that dissolves blood clots

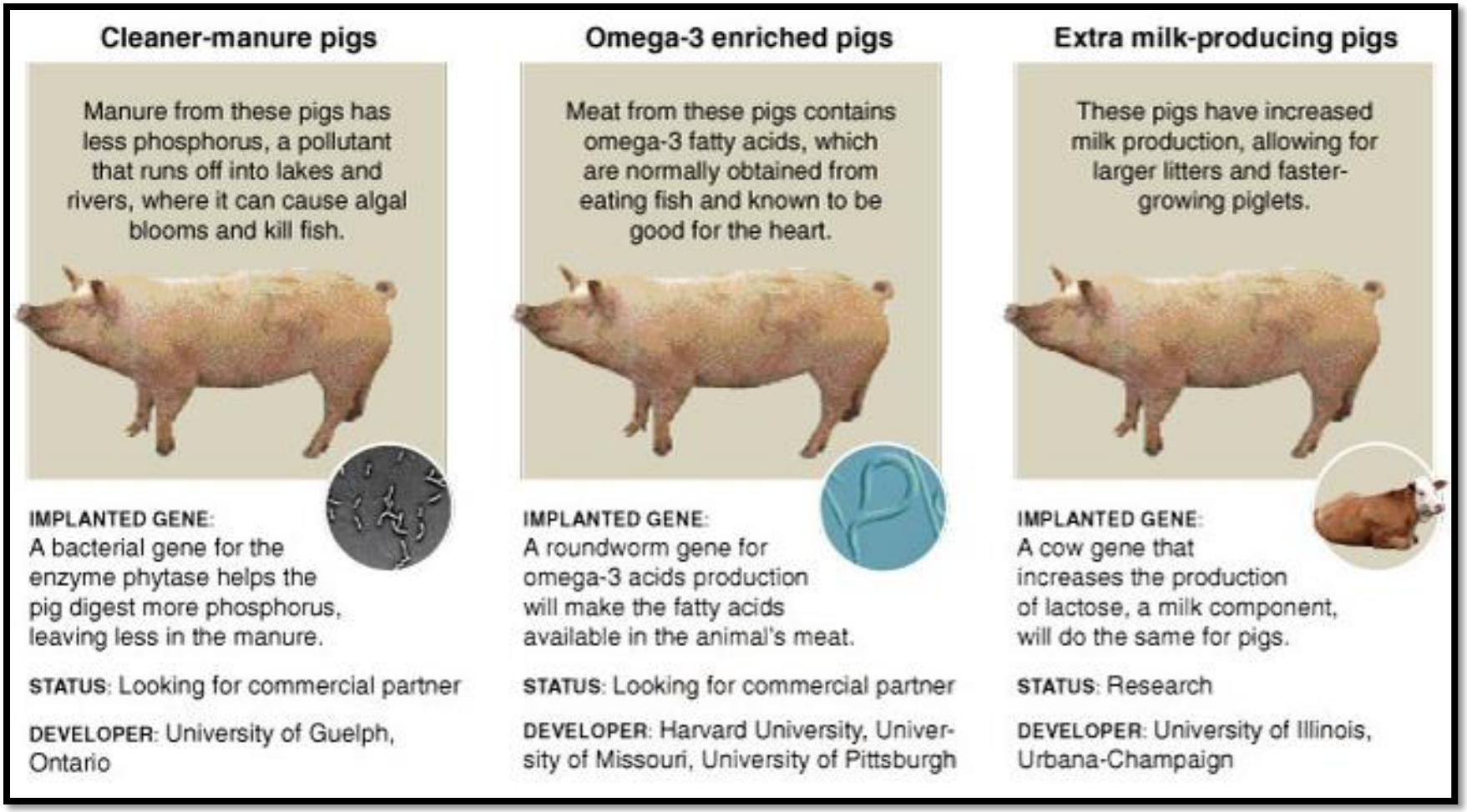
- **Glowing** zebra fish- inserted the protein for glowing from a jelly fish.

More Glowing Critters



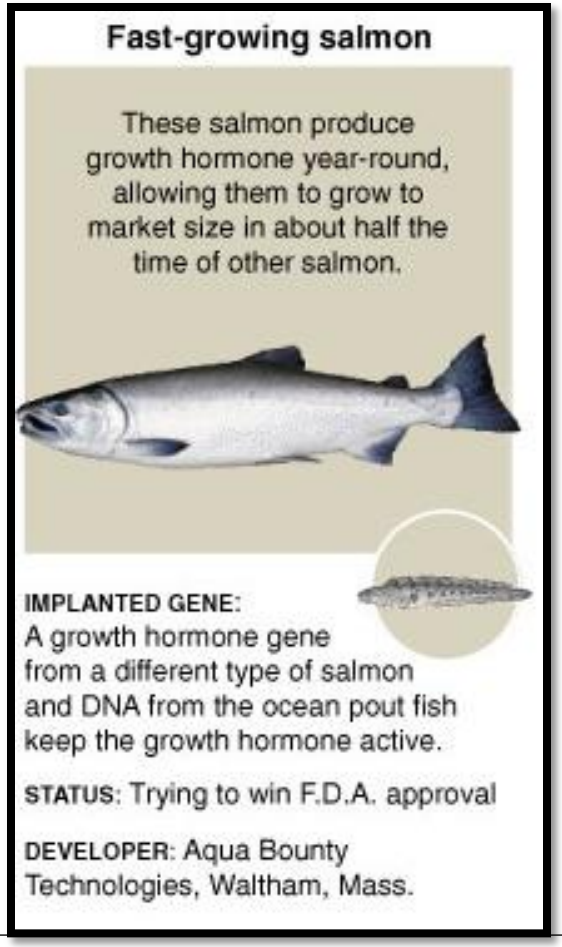
B.) Transgenic Animals:

- Pigs that can produce **less phosphorus**, contain Omega-3 fats, and produce more milk

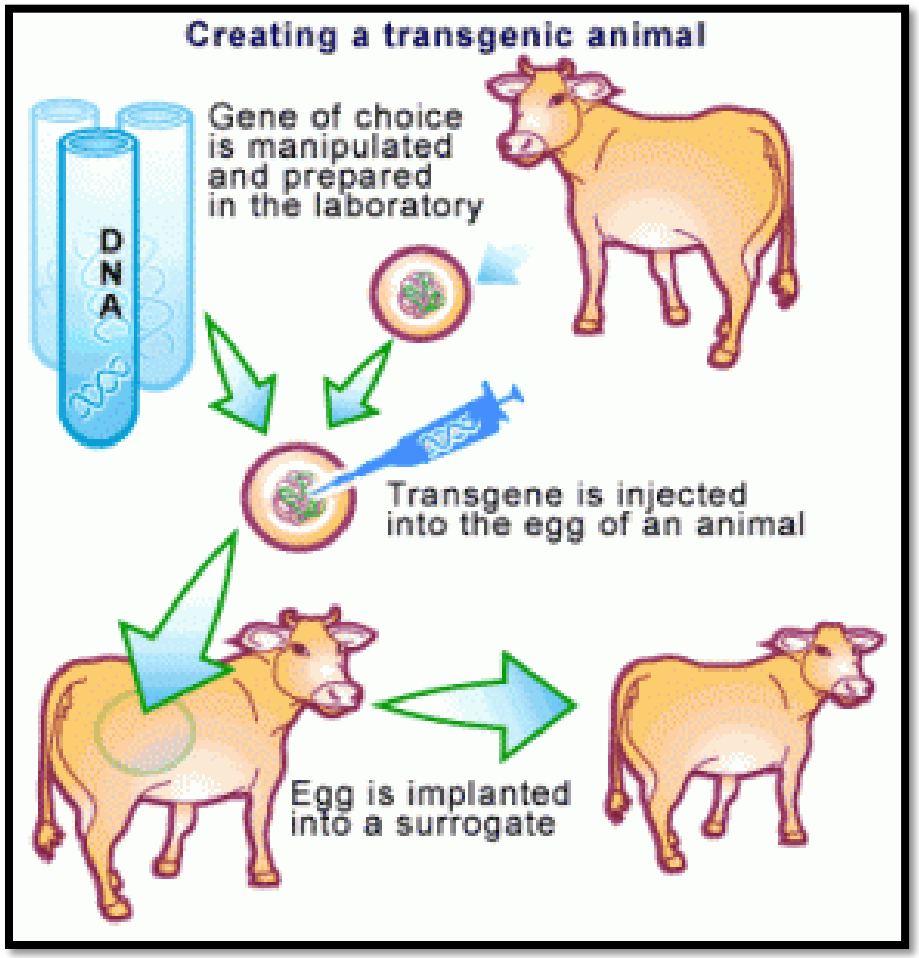


B.) Transgenic Animals:

- **Fast-Growing Salmon**- Atlantic salmon that have been given a growth-hormone gene from the Chinook salmon to make lager in ½ the time

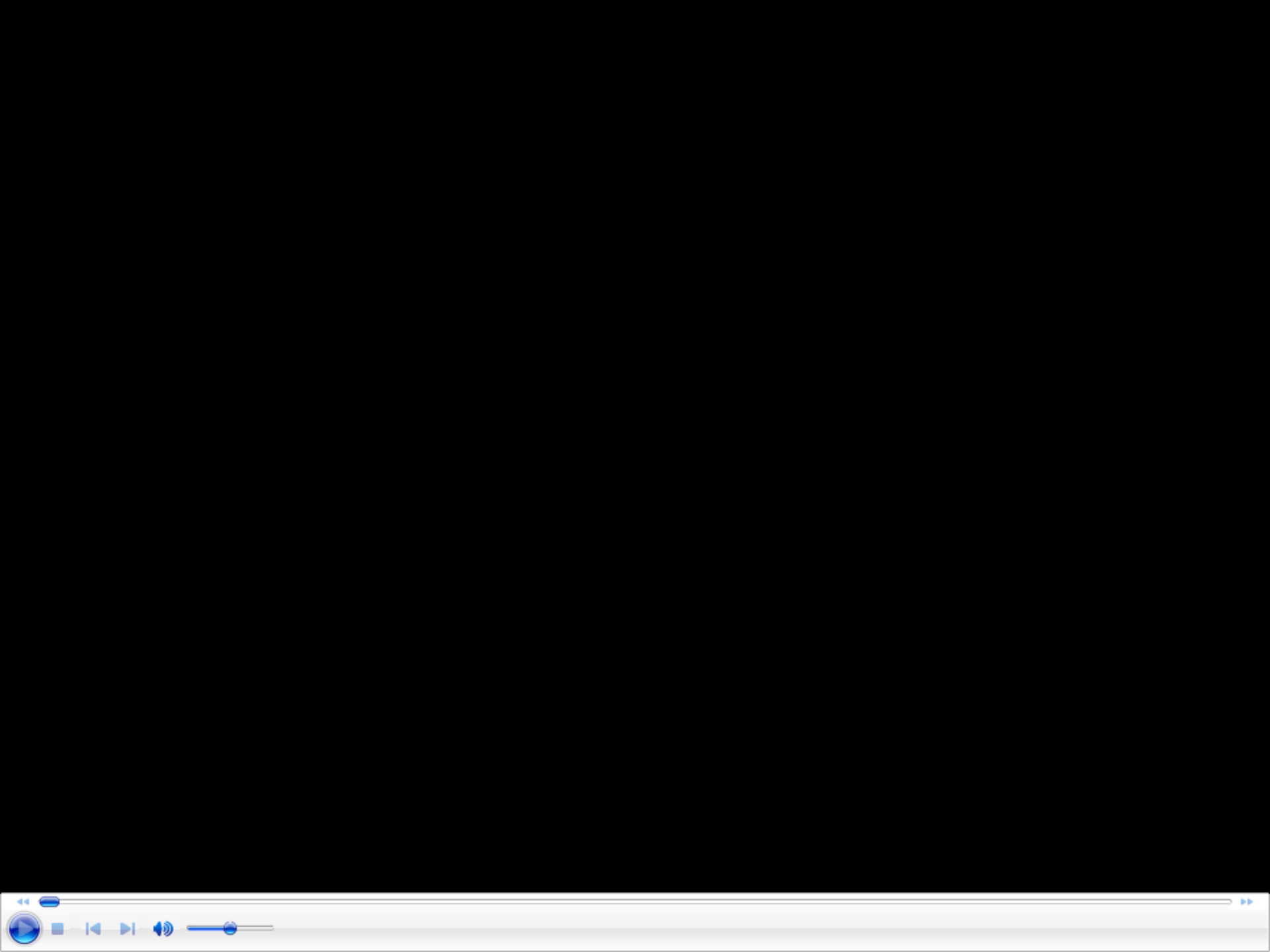


How to Create a Transgenic Animal



- Desired DNA is added to an egg cell.

Transgenics Video (next slide)



VI. PROS & CONS OF BIOTECHNOLOGY

PROS

- Disease resistant crops
- **New** vaccines & medications (insulin, human growth hormone)
- **Bigge**r livestock- more meat, milk, wool etc.
- Possible **cures** for diseases
- Environmentally friendly organisms (envio-pig, less methane producing cows, etc)

CONS:

- Unpredictable- technology is new & no guarantee that products free of **side affects**
- **Money**- companies patent genes & demand high prices
- Unexpected impacts of genetically modified organisms and biotechnology processes on the environment
- **Biological weapons** could be created using biotechnology
- Concerns over the safety and ethics of incorporating GMO's into food for human consumption
  - **Allergens**

VII. GENETICALLY MODIFIED FOODS (GM FOOD)

What do you think about eating genetically modified foods?

"Two breakthroughs—imitation eggs made of soybeans and imitation soybeans made of eggs."

"I hope there's nothing genetically modified in this"

What is a Genetically Modified (GM) Food?

- Foods that contain an **added** gene sequence
- Foods that have a **deleted** gene sequence
- Animal products from animals fed GM feed
- Products produced by GM organisms

What Foods Contain GMOs?

- As of 2012, the USDA reports the following percent of all crops grown in the U.S. are genetically modified:

- • Cotton – 94%
  - • Soybeans – 93%
  - • Sugar Beets – 90%
  - • Canola – 88%
  - • Corn – 88%
  - • Hawaiian papaya – more than 50%
  - • Zucchini and Yellow Squash – small %
  - • Quest brand tobacco – 100%
  - • Alfalfa (recently approved by the FDA; widely fed to animals to produce meat and milk)

Labeling GM Foods:

- Food manufacturers may indicate through **voluntary** labeling whether foods have or have not been developed through genetic engineering.

- GM foods in the U.S. are required to be labeled only if the nutritional value is changed or a new **allergen** is introduced.

Benefits of GE Crops Used For Foods

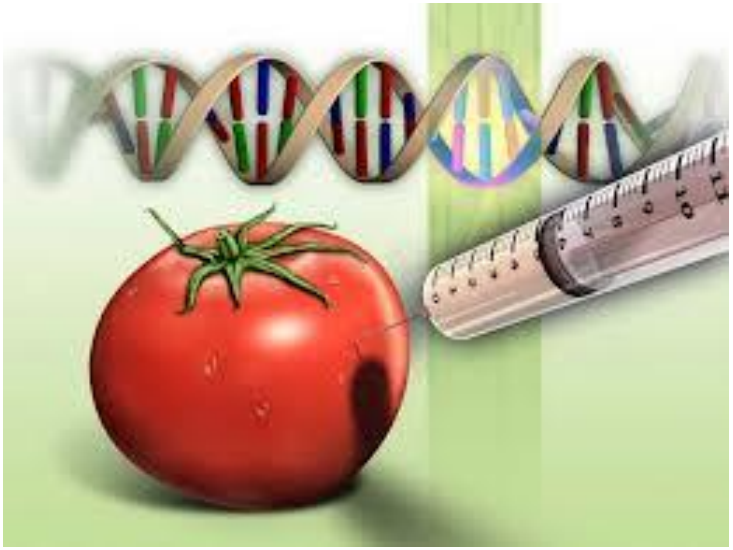
- **Reduced** use of chemical pesticides
- Less runoff of chemicals into waterways
- Greater use of farming practices that prevent soil erosion
- **Higher** profits for farmers
- Less fungal contamination
- More nutritious foods

Benefits of GE Crops Used For Foods

- Easing of world **hunger**
  - Crops that can be grown in poor soil
  - Drought resistant crops
  - Salt-tolerant crops

Benefits of GE Crops Used For Foods

- Improved **crop** quality
  - Frost resistant crops
  - Disease resistant crops
  - Flood resistant crops
- Improved nutritional quality

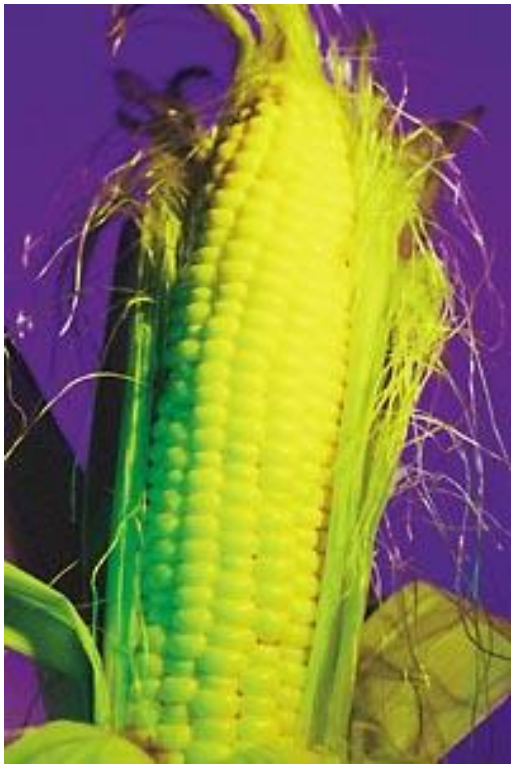


Concerns of GE Crops Used For Foods

- GMOs are now present in the **majority** of processed foods consumed in the U.S. (unless they're organic).
- US cancer rates are the **7th** highest in the world, having skyrocketed during the *same* timeframe GMOs were introduced into our food.

Concerns of GE Crops Used For Foods

- Insects might develop **resistance** to pesticide-producing GM crops
- Herbicide-tolerant crops may cross-pollinate weeds, resulting in “super weeds”
- Soil is being saturated with toxins, due to the ever-increasing use of herbicides and pesticides to counteract resistant weeds and insects.



Concerns of GE Crops Used For Foods

- Certain gene products may be **allergens**, thus causing harm to human health
- There may be unintended harm to wildlife and beneficial insects
  - **Bees**, which we rely upon to pollinate all of our crops, are dying at unprecedented rates as a direct result of GMO crops.