Transgenic or Genetically Modified Crops

terms to know

TRANSGENE- It is a foreign gene or genetic material that has been transferred naturally or by any of a number of genetic engineering techniques from one organism to another.

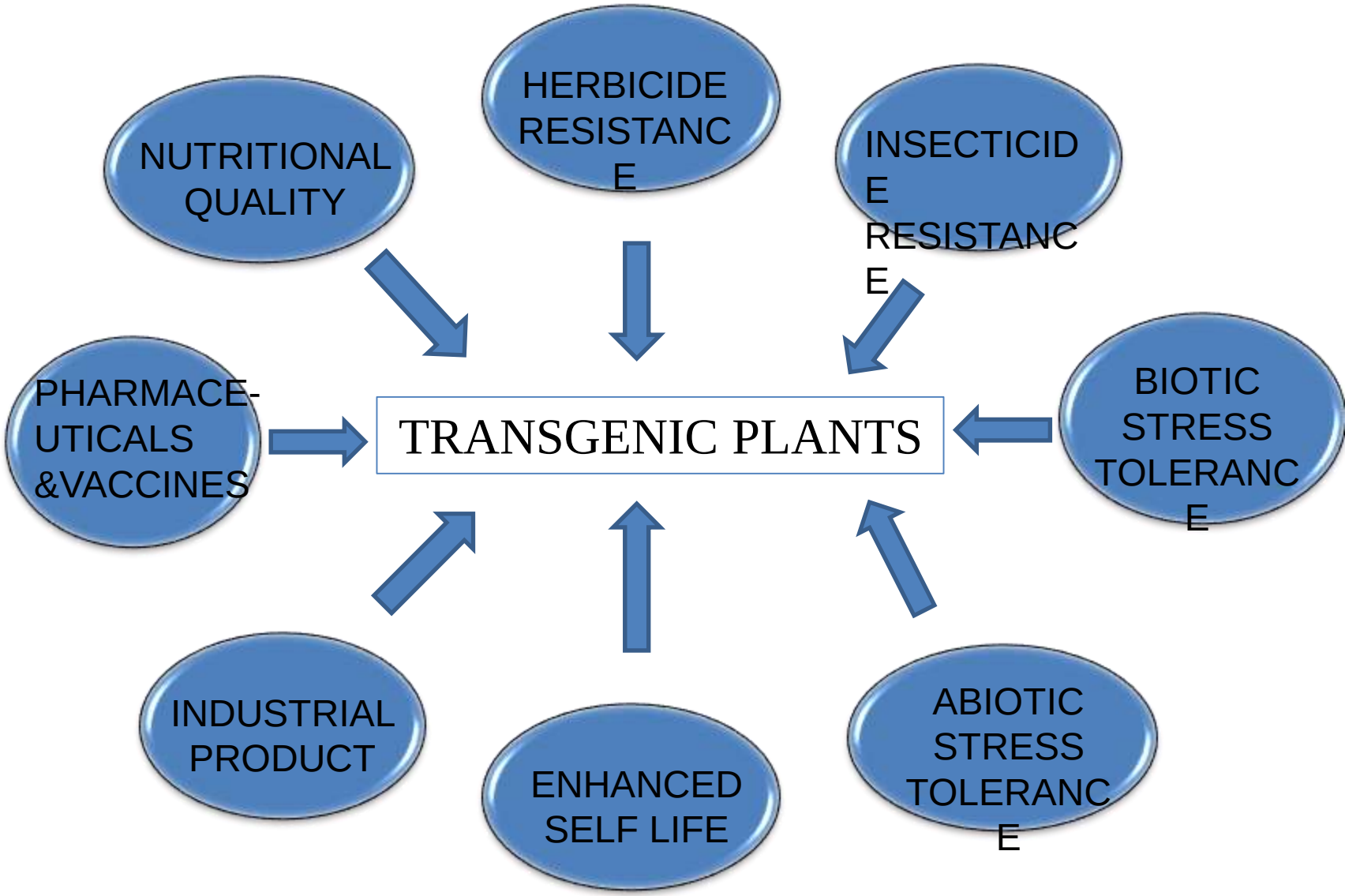
TRANSGENESIS- The phenomenon of introduction of exogenous DNA into the genome to create and maintain a stable and heritable character.

TRANSGENIC PLANTS- The plant whose genome is altered by adding one or more transgenes are known as transgenic plants.

history

1982	• 1st transgenic plant produced which is an antibiotic resistance tobacco plant.
1984	• 1st successful plant genetic engineering experiments using caulimovirus vector.
1994	• 1st genetically modified crop approved for sale in U.S. was FlavrSavr tomato.
1995	• 1st pesticide producing crop, Bt Potato was approved by U.S. Environmental Protection Agency
1996	• 1st genetically modified flower Moondust, bluish colored carnation, was introduced.
2000	• Golden rice with β- carotene developed with increased nutrient value.
2013	• 1st genetically engineered crop developed by Robert Fraley, Marc Van Montagu &Marry Dell Chilton were awarded World Food Prize.

Why transgenic plants?



GENE TRANSFER METHODS

BIOLOGICAL METHODS

- Agrobacterium mediated gene transfer
- Plant virus vectors

PHYSICAL METHODS

- Electroporation
- Microprojectile
- Microinjection
- Liposome Fusion

CHEMICAL METHODS

- Polyethylene glycol mediated
- Diethylaminoethyl dextran mediated

APPLICATIONS

- Transgenic plants have various applications -:

RESISTANCE TO BIOTIC STRESS

1) INSECT RESISTANCE

2) VIRUS RESISTANCE

3) FUNGAL AND BACTERIAL RESISTANCE

RESISTANCE TO ABIOTIC STRESS

1) HERBICIDE RESISTANCE

2) GLYPHOSATE RESISTANCE

IMPROVEMENT OF CROP YIELD & QUALITY

1) EXTENDED SELF LIFE OF FRUITS

2) IMPROVED NUTRITION

3) IMPROVED COLORATION

PRODUCTION OF LOW-COST PHARMACEUTICALS

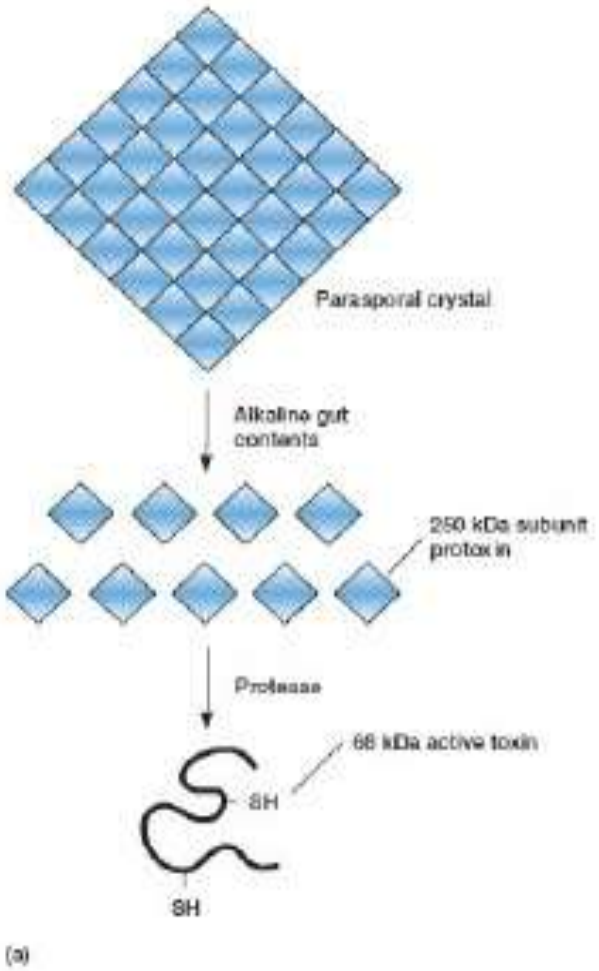
1) EDIBLE VACCINES

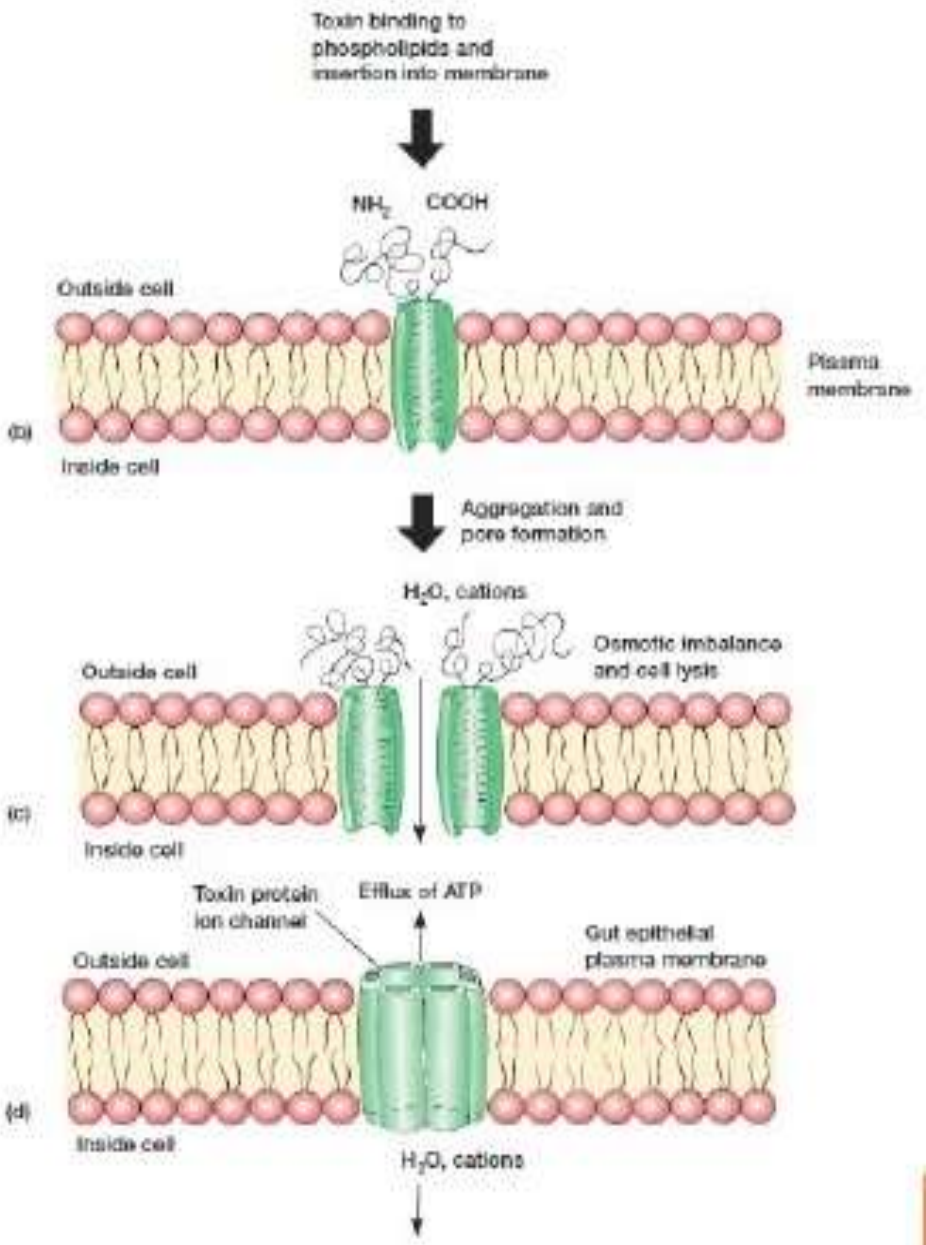
2) ESSENTIAL PROTEINS

Insect resistant plants

- It is estimated that about 15% of the world's crop yield is lost due to insects or pests.
- *Bacillus thuringiensis* was first discovered by Ishiwaki in 1901. It is a gram negative soil bacterium.
- Most of the Bt toxins are active against Lepidopteron larvae, while some of them are specific against Dipterans and Coleopteran insects.
- Different cry protein produced by Bacillus:
  Cry I : kills butterflies and moths
  Cry II : kills butterflies and flies
  Cry III : kills beetles
  Cry IV : kills only flies
- Plant made only low levels of toxin because they are designed to express well in bacteria and not in plants as they are produced from bacterium.
- Insect toxin gene was altered by changing many bases of the third position of the redundant codon to improve its toxicity.

Action of Bt toxin





Virus resistant plants

- Plants may be engineered with genes for resistance to viruses, bacteria, and fungi.
- Virus-resistant plants have a viral protein coat gene that is overproduced, preventing the virus from reproducing in the host cell, because the plant shuts off the virus protein coat gene in response to the overproduction.
- Coat protein genes are involved in resistance to diseases such as cucumber mosaic virus, tobacco rattle virus, and potato virus X.

Herbicide resistance

- Weeds are unwanted and useless plants that grow along with the crop plants. To tackle these, herbicides are used.

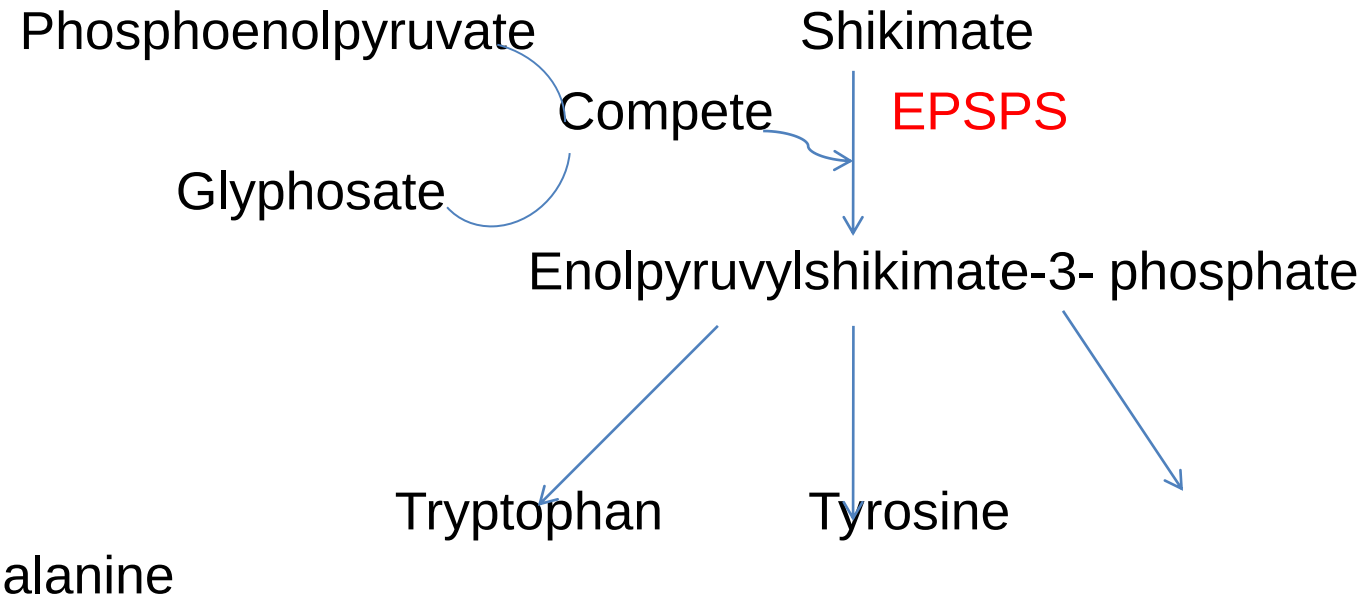


Fig: Glyphosate competes with the phosphoenolpyruvate in the EPSPS catalyzed synthesis of enolpyruvylshikimate-3- phosphate and inhibits synthesis of tryptophan, tyrosine and phenylalanine.

- EPSPS- Enolpyruvylshikimate-3- phosphate synthase

- The 1st crops to be engineered for glyphosate resistance were produced by Monsanto Co. and called “Roundup Ready”.

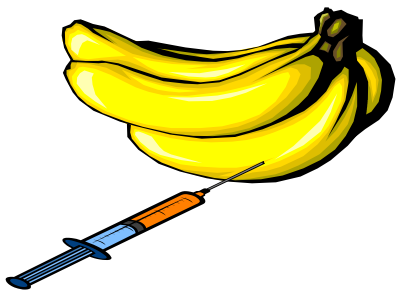
Vaccine production

- Potatoes have been studied using a portion of the *E. coli* enterotoxin in mice and humans and then transgenic potatoes were produced. Ingestion of this transgenic potato resulted in satisfactory vaccinations and no adverse effects.

- Other candidates for edible vaccines include banana and tomato, and alfalfa, corn, and wheat are possible candidates for use in livestock.

- Edible vaccines are vaccines produced in plants that can be administered directly through the ingestion of plant materials containing the vaccine. Eating the plant would then confer immunity against diseases.

One focus of current vaccine effort is on hepatitis B. Transgenic tobacco and potatoes were engineered to express hepatitis B virus vaccine.



GOLDEN RICE

- Transgenic technology produced a type of rice that accumulates β-carotene in rice grains.
- When it is consumed, β-carotene is converted into vitamin-A.
- It contains 37 mg/g of carotenoid of which 84% is β-carotene.

Normal rice

Golden rice

FLAVR-SAVR TOMATO

This is produced by antisense technology.

The polygalactouronase gene, which is responsible for fruit decay is silenced.

Biopolymers and plants

a) Plant seeds may be a potential source for plastics that could be produced and easily extracted.

b) A type of PHA (polyhydroxylalkanoate) polymer called "poly-beta-hydroxybutyrate", or PHB, is produced in *Arabidopsis* or mustard plant.

c) PHB can be made in canola seeds by the transfer of three genes from the bacterium *Alcaligenes eutrophus*, which codes for enzymes in the PHB synthesis pathway.

d) A polymer called PHBV produced through *Alcaligenes* fermentation, which is sold under the name Biopol.

TEARLESS ONION

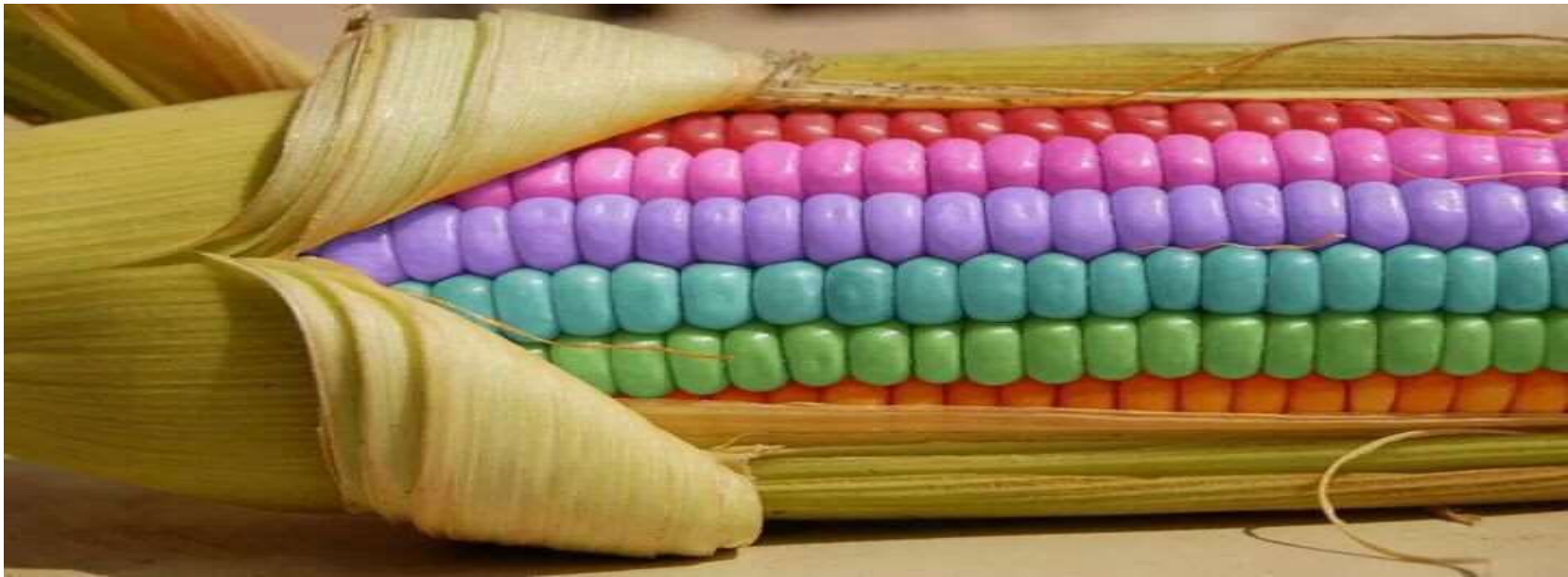
Fig: Produced by Gene Silencing

COLOURFUL CAULIFLOWER

PURPLE TOMATOES

PURPLE ROSE

COLOURFUL CORNS



What is Genetically modified crop?

- **Genetically modified crops (GMCs, GM crops, or biotech crops) are plants used in agriculture, the DNA of which has been modified using genetic engineering methods.**

Name of some genetically modified crops

Food	Modification
Soybeans	Herbicide resistant gene taken from bacteria inserted into soybean.
Corn, field	New genes added/transferred into plant genome.
Tomatoes	A reverse copy of the gene responsible for the production of PG enzyme added into plant genome.
Sugar cane	New genes added/transferred into plant genome.
Rice	“Golden rice" Three new genes implanted: two from daffodils and the third from a bacterium.

Advantages of GM Foods

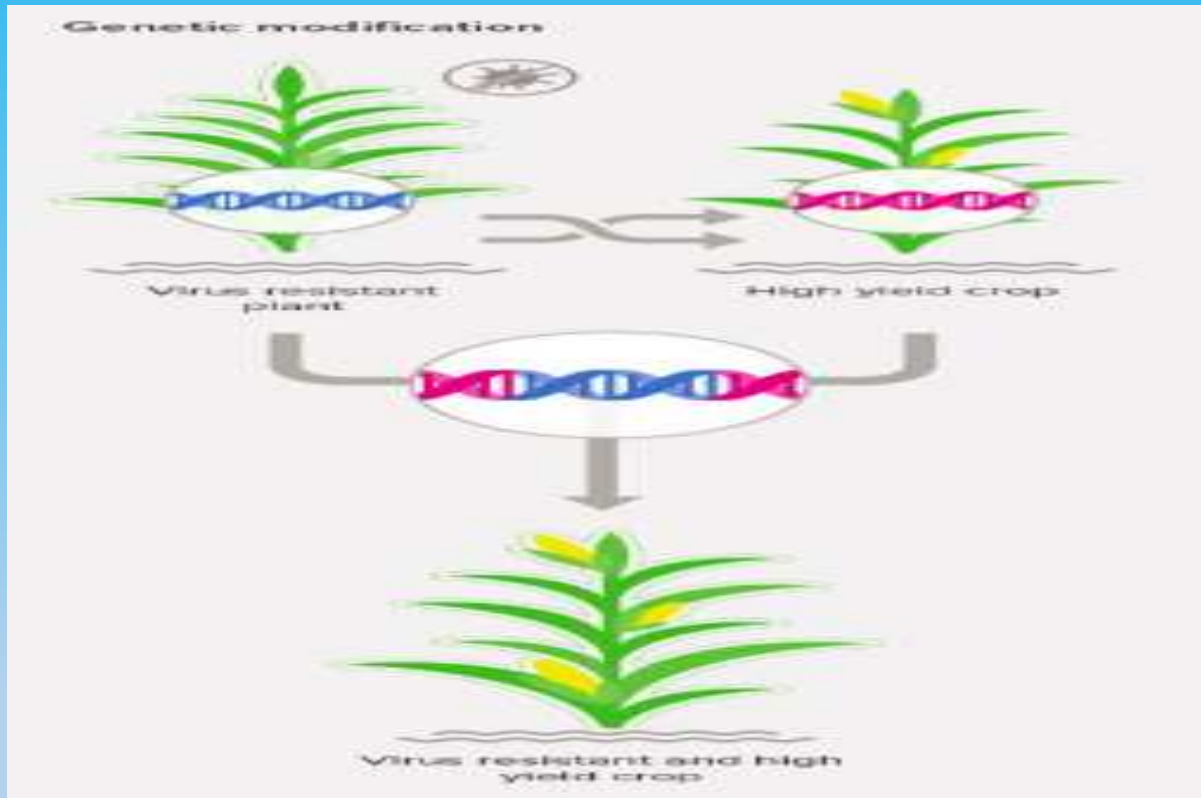
- **Crops**
  - Enhanced taste and quality
  - Reduced maturation time
  - Increased nutrients, yields, and stress tolerance
  - Improved resistance to disease, pests, and herbicides
  - New products and growing techniques
- **Animals**
  - Increased resistance, productivity, hardiness, and feed efficiency
  - Better yields of meat, eggs, and milk

The disadvantages of genetically modified crops are:

- Proteins produced by GM organisms may cause allergies and other diseases
- Persistent release of insecticidal proteins by GMO's may disrupt the biological activity of the soil.
- Horizontal transfer of antibiotic resistant genes from transgenic crops to bacteria
- The genetically modified crops may eliminate the indigenous varieties through competition for minerals and nutrients
- Environmental risk of crop developed using GMO's
- Genetically modified crops may turn benign organisms into destructive pests.

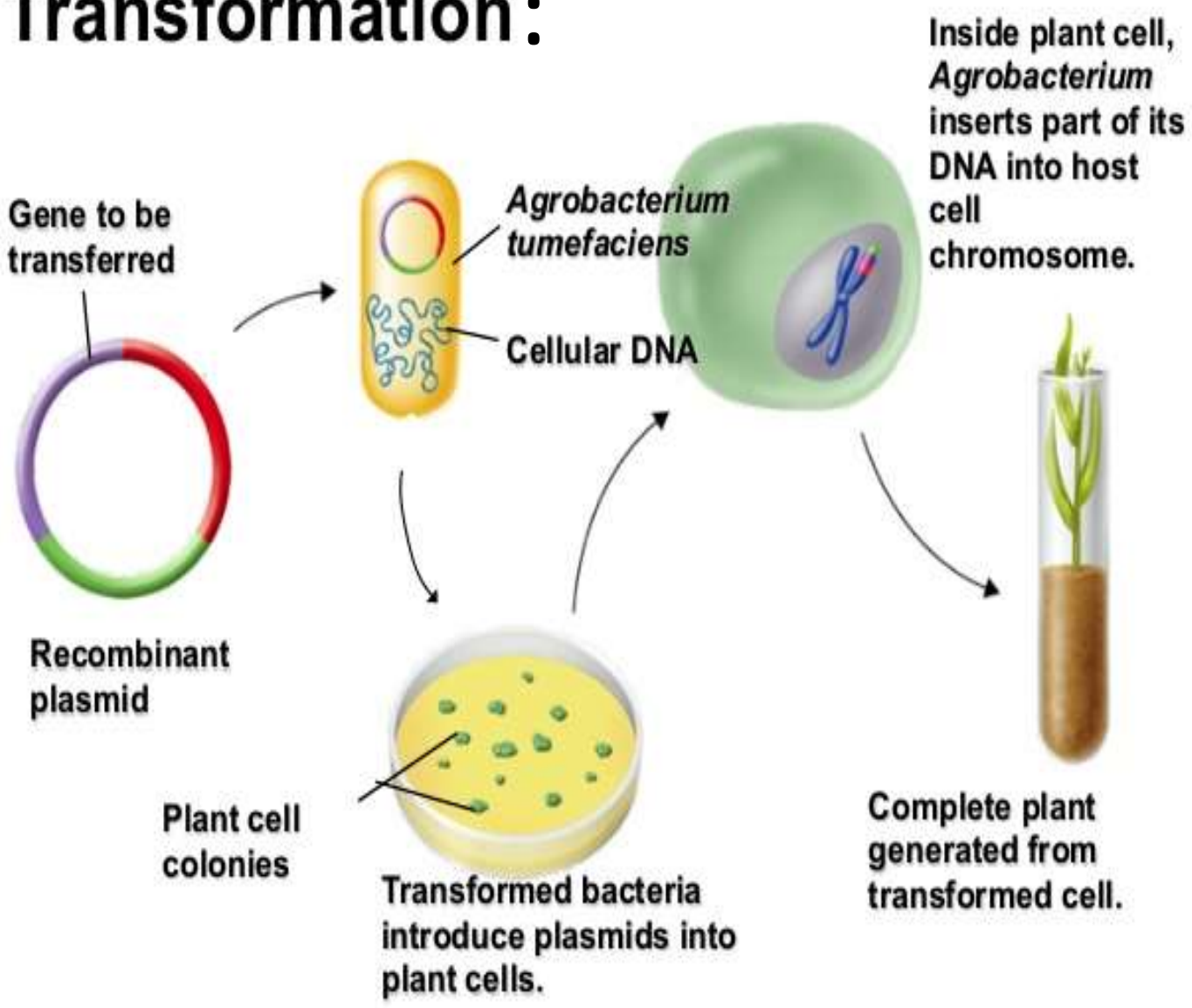
Selection of Plants, Breeding, Isolation and Insertion of desired gene :

- **To produce a new generation of plants.**
- **To produce crops with improved characteristics by changing their genetic makeup.**
- **The gene(s) of interest is inserted into the plasmid using recombinant DNA (rDNA) techniques.**



Selection of plant Transformation:

Selection of plant transformation involves demonstrating that the gene has been inserted and is inherited normally.



Specificity of Genetic Modification

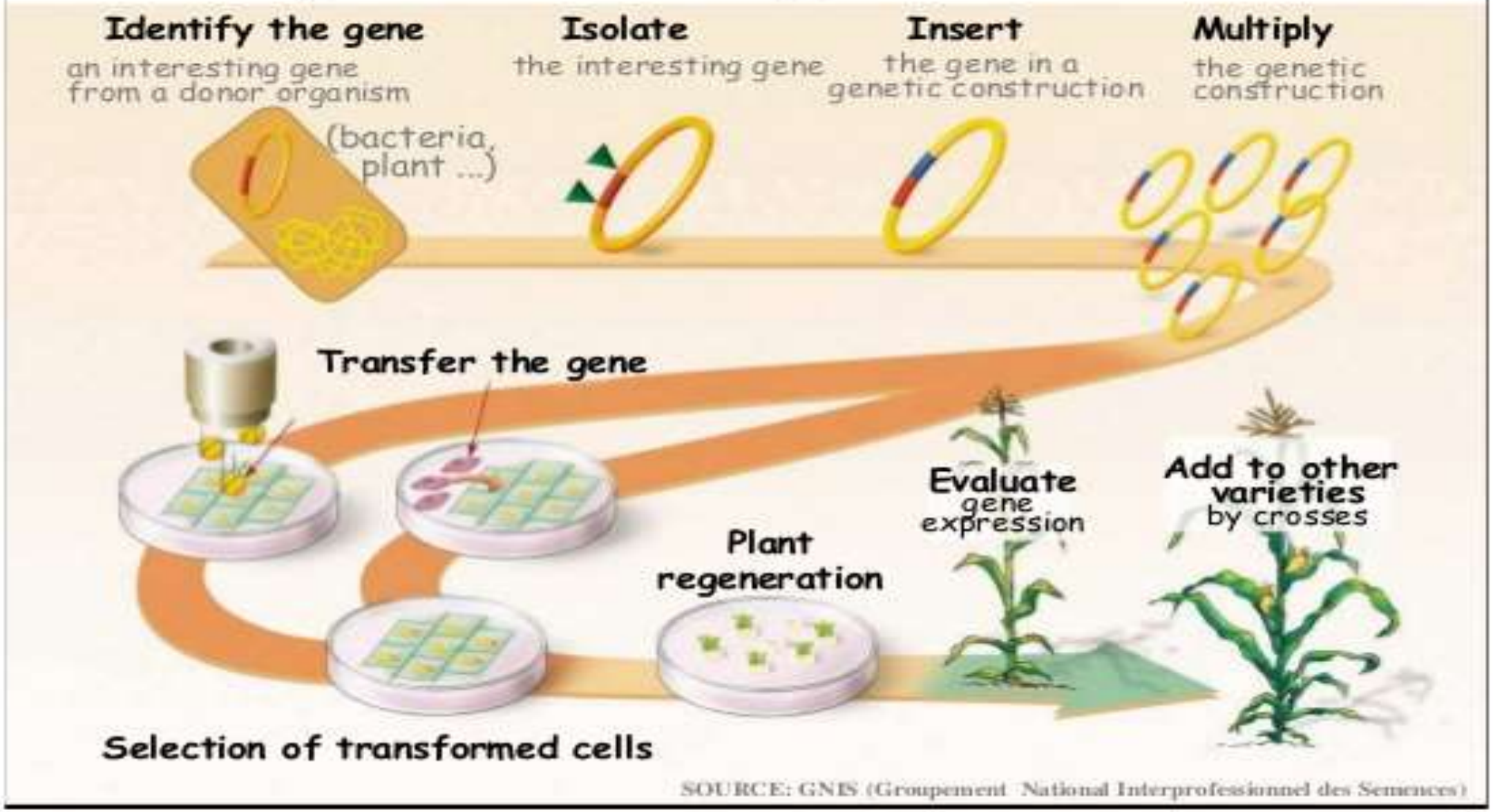
Identification and isolation of specific genes with defined function

Insertion of specific genes into a crop species to promote desirable characters

GM progeny can be selected for the product or activity of specific genes with a defined function

There are no “surprises” from unknown genes transferred along with the planned cross

The steps involved in genetic modification



SOURCE: GNIS (Groupement National Interprofessionnel des Semences)

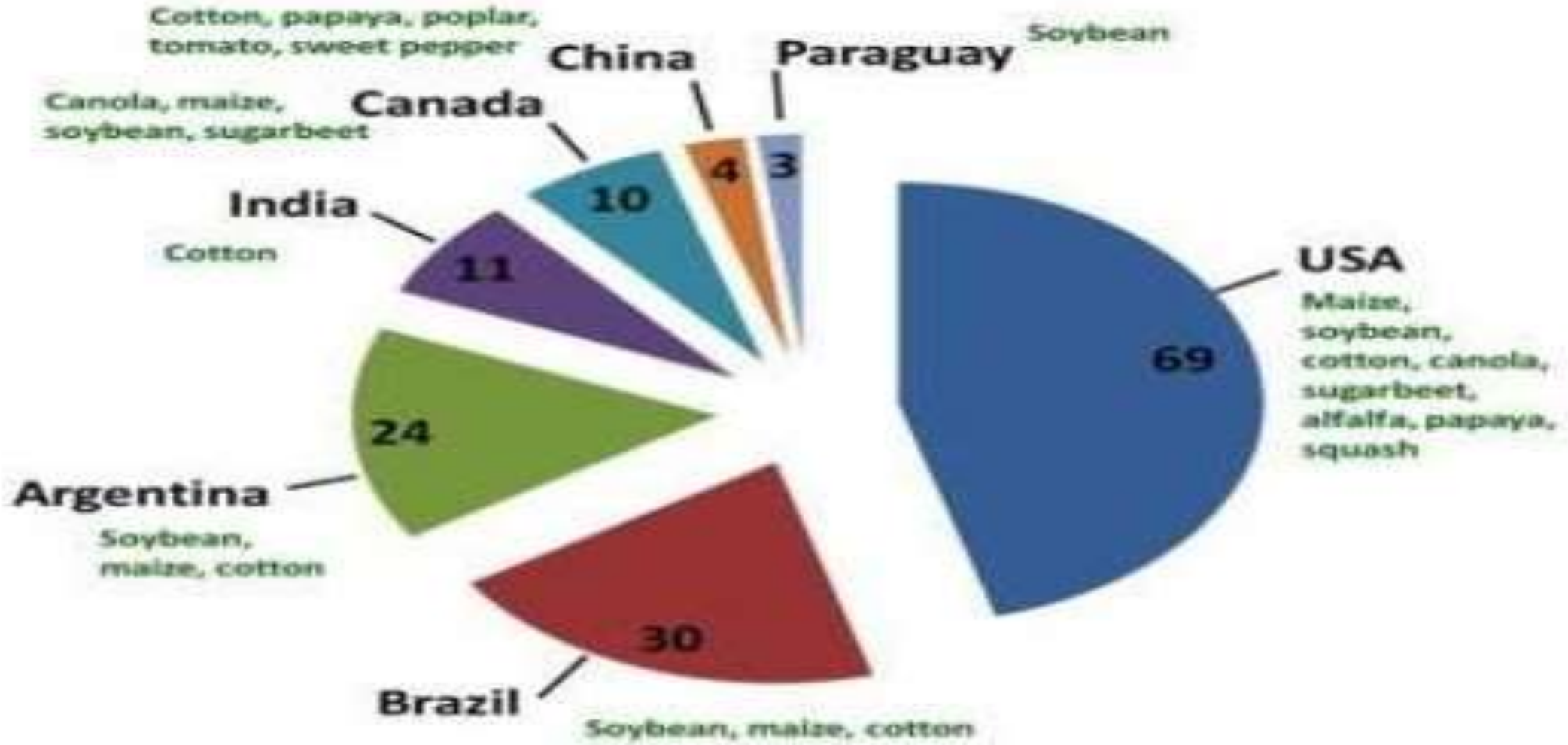


Figure 1: Schematically Global Area of Biotech Crops

Production of genetically engineered high yield and submergene tolerance of rice varieties:

- **Submergence tolerant high yielding rice variety was developed using BR11 in Bangladesh.**

Golden rice

Golden rice is a variety of Oryza sativa rice produced from genetic engineering.

- **The creation of plants that make or accumulate micronutrients**
- **Main purpose is to provide pro-vitamin A to third world, developing, countries where malnutrition and vitamin A deficiency are common**
- **Vitamin A deficiency (VAD) can negatively affect growth and development, cause blindness, interfere with the growth of epithelial cells, and suppress the immune system**
- **Vitamin A can be synthesized from the βcarotene found in green leafy vegetables and yellow fruits or vegetables, and it can be obtained from certain animal products (liver, egg yolk, etc.).**

Advantages:

- Golden rice provides more quantity of Vitamin–A.
- Easy distribution, when released to needy.
- Cheaper option to supply Vitamin–A requirement compared to other supplementary measures.
- Sustainable option as once released for common cultivation, can be cultivated in every growing season by farmer saved seeds, therefore, no need for yearly budgetary investments for distribution.

Disadvantage of Golden Rice

- Environmental impact
- Excess vitamin and mineral intake/ toxicity
- Health risks
- Profiting- Some GM Rice developers develop GM Rice with added benefits such as higher yields or disease resistance, but also prevent the seeds of the strain of rice from growing by making the transgenic crop sterile. This means the farmer has to buy new seeds from the developer every year, increasing the profits of the GM Rice developer.

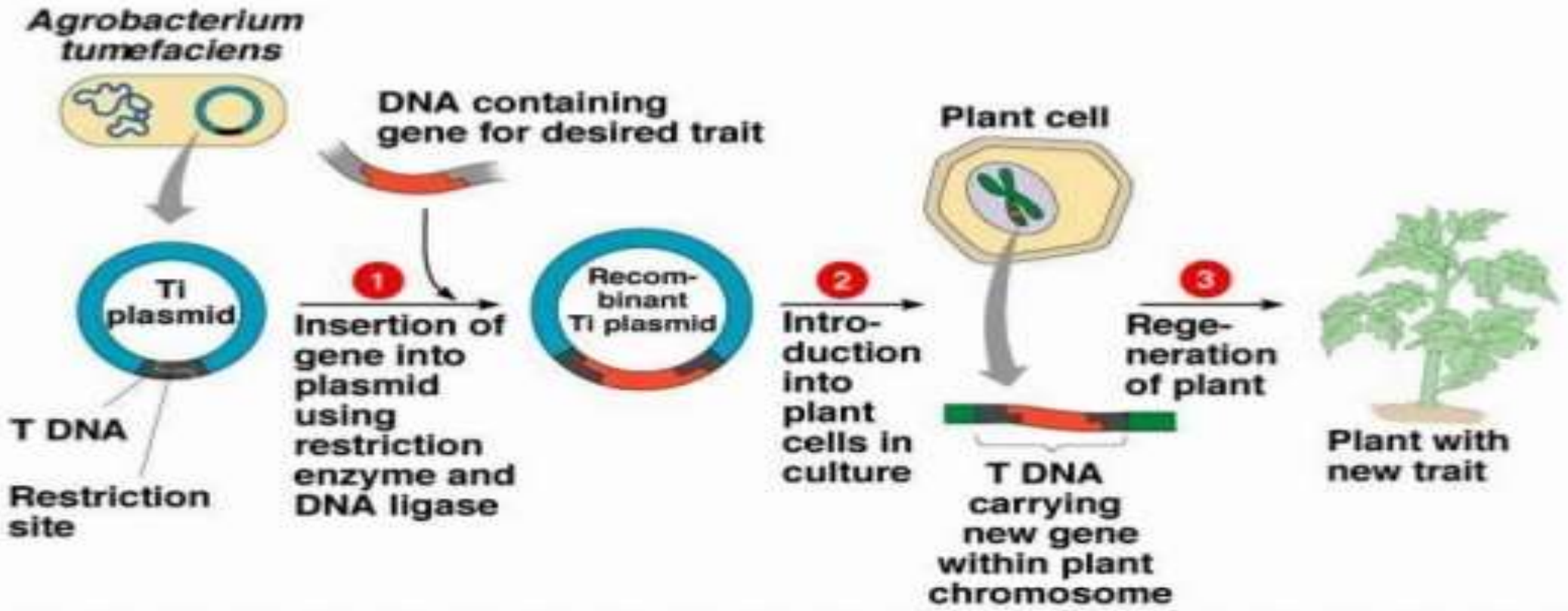
Some Initiatives in Bangladesh:

- **Dhaka University, Bangladesh Agricultural University (BAU), Rajshahi University (RU), Bangladesh Sugarcane Research Institute (BSRI), BARI, BRRI, and BINA have started genetic fingerprinting and genetic engineering research.**
- **BRRI developed vitamin A-enriched Golden Rice.**
- **BARI developed fruit and shoot borer resistant Bt brinjal.**
- **The Department of Botany in Dhaka University started a program on plant biotechnology.**

Genetic Transformation in Wheat

- **Genetic transformation is fundamental to wheat molecular genetics and improvement through genetic engineering.**
- ***Agrobacterium*-mediated transformation and microparticle bombardment are the two widely used methods for wheat genetic transformation.**

Agrobacterium mediated Transformation.



Genetic transformation of wheat

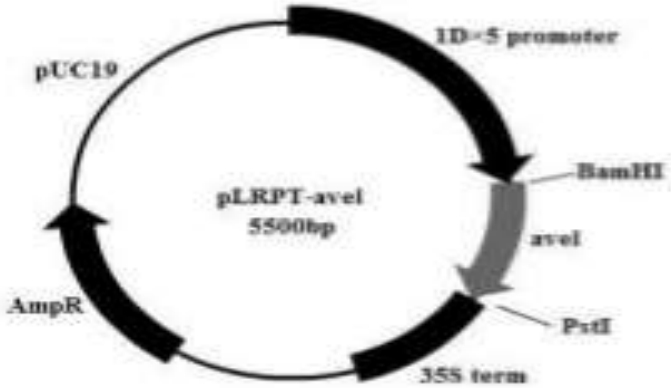


Fig.12. Schematic map of the wheat transformation vector.

Avenin-like b gene inserted between the endosperm-specific 1Dx5 promoter and the CaMV35S terminator

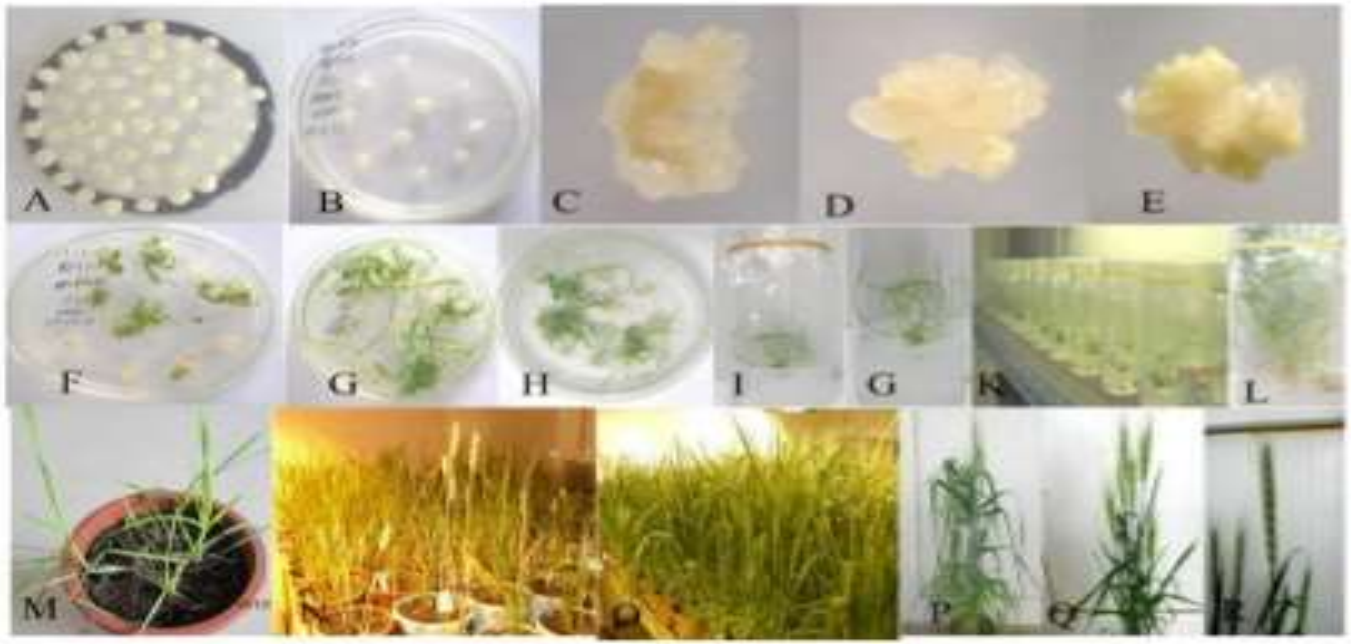
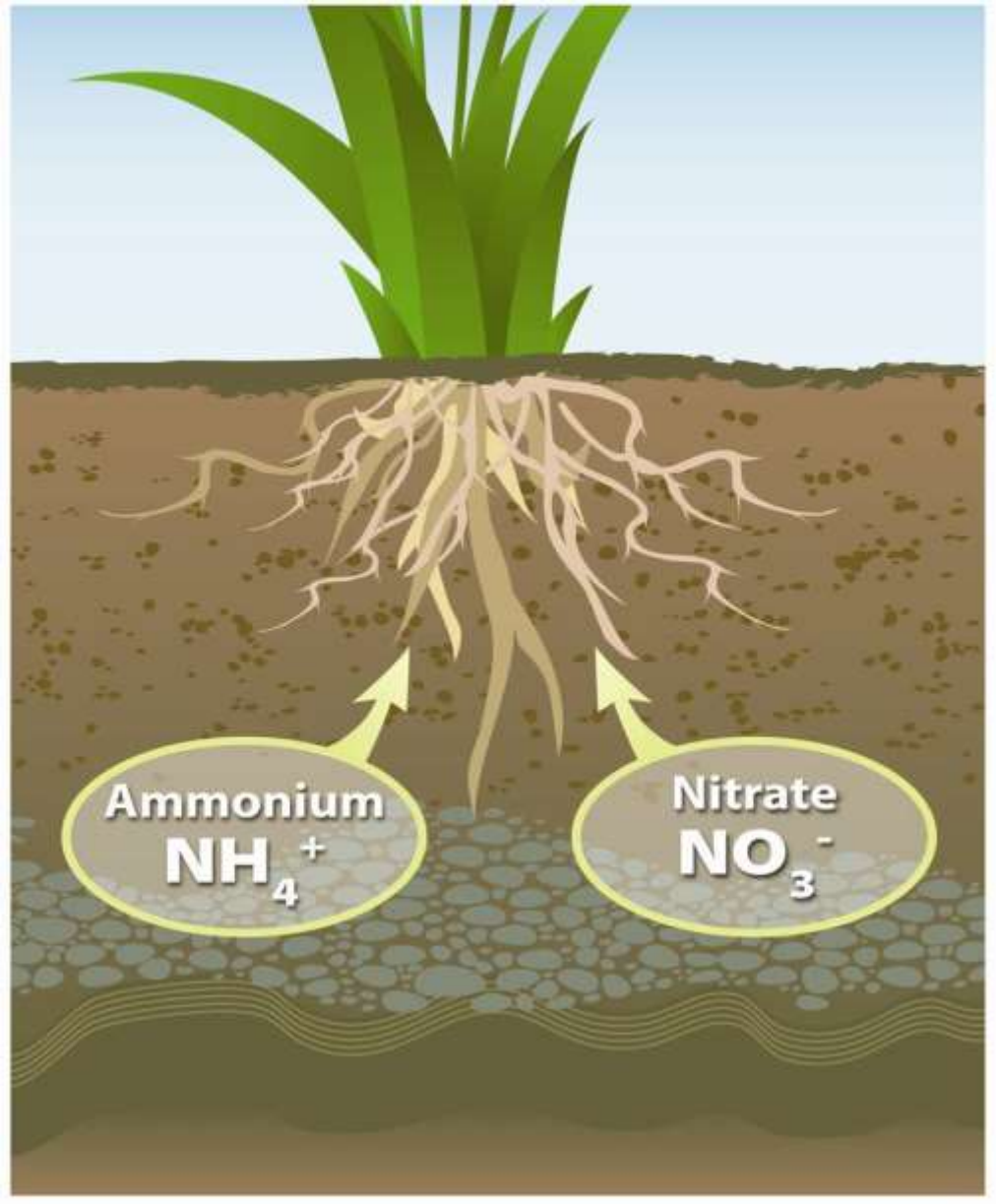


Fig.13. Regenrataion of transgenic wheat after particle bomBardment

A. The scutellum of donor wheat on target plate; **B-E.** The callus induced from wheat scutellum; **F.** The cultures after 1 weeks on regeneration medium; **G-H.** The cultures after 4 weeks on regeneration medium; **I -L.** The plantlets in culture bottle; **M-Q.** The plantlets cultured in the soil; **R.** The plantlets in culture bottle

Making nitrogen available to plants

- **Nitrogen fixation is essential for some forms of life because inorganic nitrogen compounds are required for the biosynthesis of the basic building blocks of plants, animals and other life forms.**

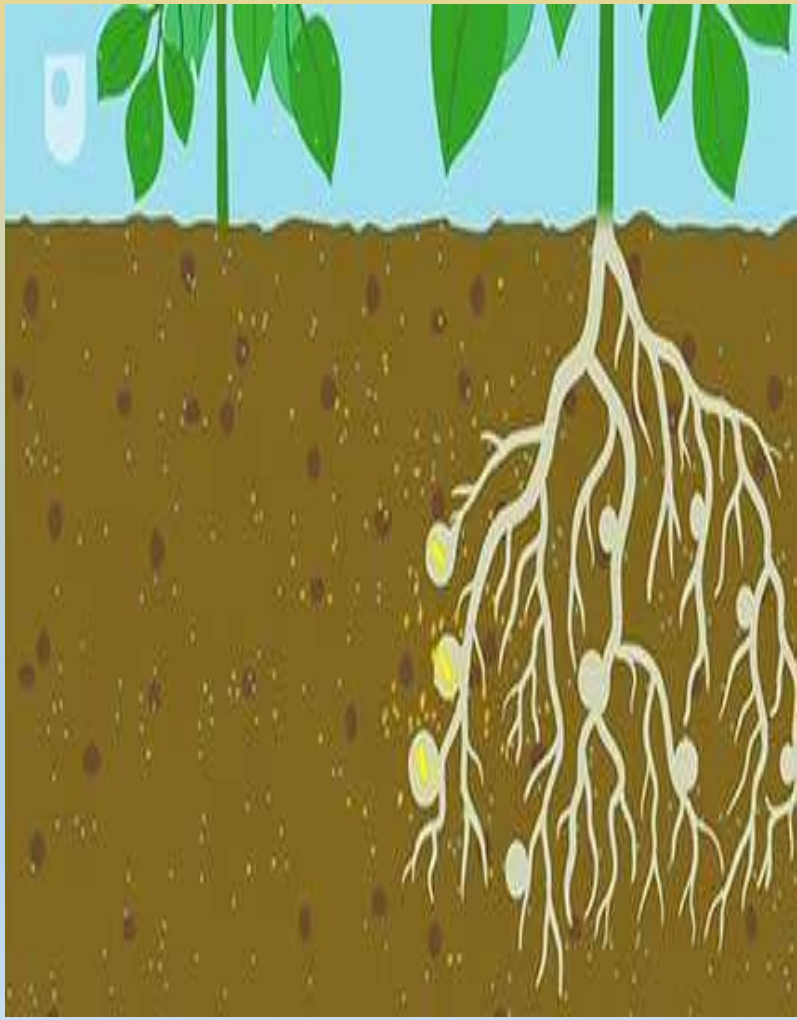


Mechanism of nitrogen fixation

- **Nitrogen fixation, natural and synthetic, is essential for all forms of life because nitrogen is required to biosynthesize basic building blocks of plants, animals and other life forms, e.g., nucleotides for DNA and RNA and amino acids for proteins.**
- Nitrogen fixation is a process by which nitrogen in the Earth's atmosphere is converted into ammonia (NH_3) or other molecules available to living organisms. Atmospheric nitrogen or molecular dinitrogen (N_2) is relatively inert, it does not easily react with other chemicals to form new compounds.

How Do Plants Fix Nitrogen?

- **Nitrogen fixing plants don’t pull nitrogen from the air on their own. They actually need help from a common bacteria called Rhizobium.**
- **The bacteria converts this nitrogen gas and then stores it in the roots of the plant. When the plant stores the nitrogen in the roots, it produces a lump on the root called a nitrogen nodule.**



Is it safe to eat GM crops?

Yes.

- There is no evidence that a crop is dangerous to eat just because it is GM. There has been no evidence of ill effects linked to the consumption of any approved GM crop.
- Before any food produced using GM technology is permitted onto the market, a variety of tests have to be completed. The results from these tests, including results from animal feeding trials, are considered by the authorities responsible for determining the safety of each new GM product.

Future prospects of GM Crops

- Future benefits might include:
  - food without allergens; (i.e. anyone could eat nuts)
  - grains, fruit & vegetables with improved nutrition (multi-vitamin potatoes=healthy fast food french fries!)
  - longer shelf life and better taste (reduced food waste due to spoilage)
  - rice enhanced with iron (prevent anemia)
  - foods used as vaccines (bye-bye needles)
  - Many more possibilities

Food safety assessment principles of GM foods

The codex safety assessment principle for GM foods require investigation of :

-Direct health effects (toxicity).

- Tendency to provoke allergic reaction (allergenicity).

-specific components for to have nutritional or toxic properties.

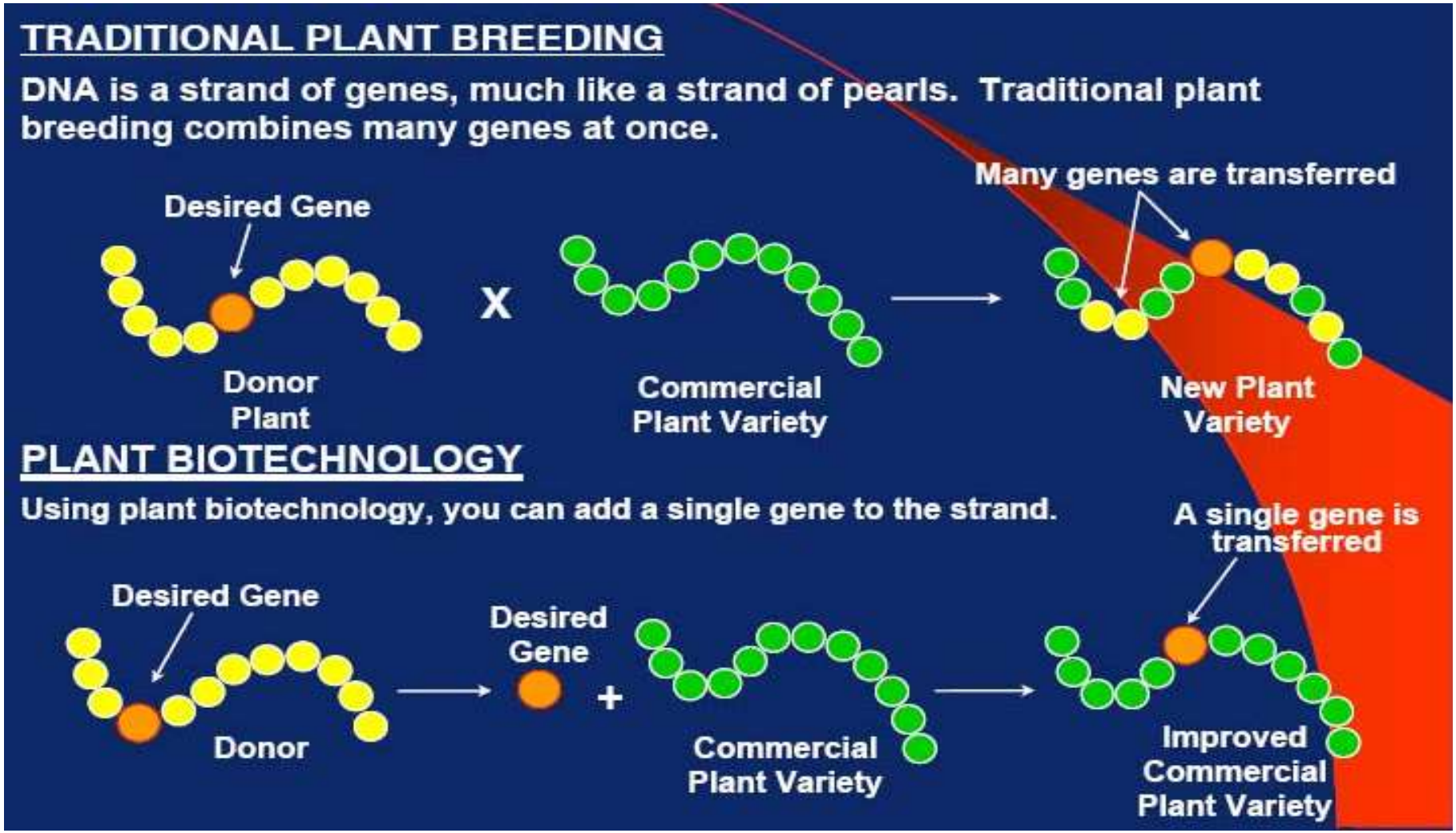
- The stability of the inserted gene.

-Nutritional effects associated with the specific genetic modification.

- Any unintended effects which could result from the gene insertion.

Why to make transgenic crops?

Due to limitations of conventional breeding for attaining the desirable traits use of recombinant DNA technology has been taken advantage of and development of transgenics started

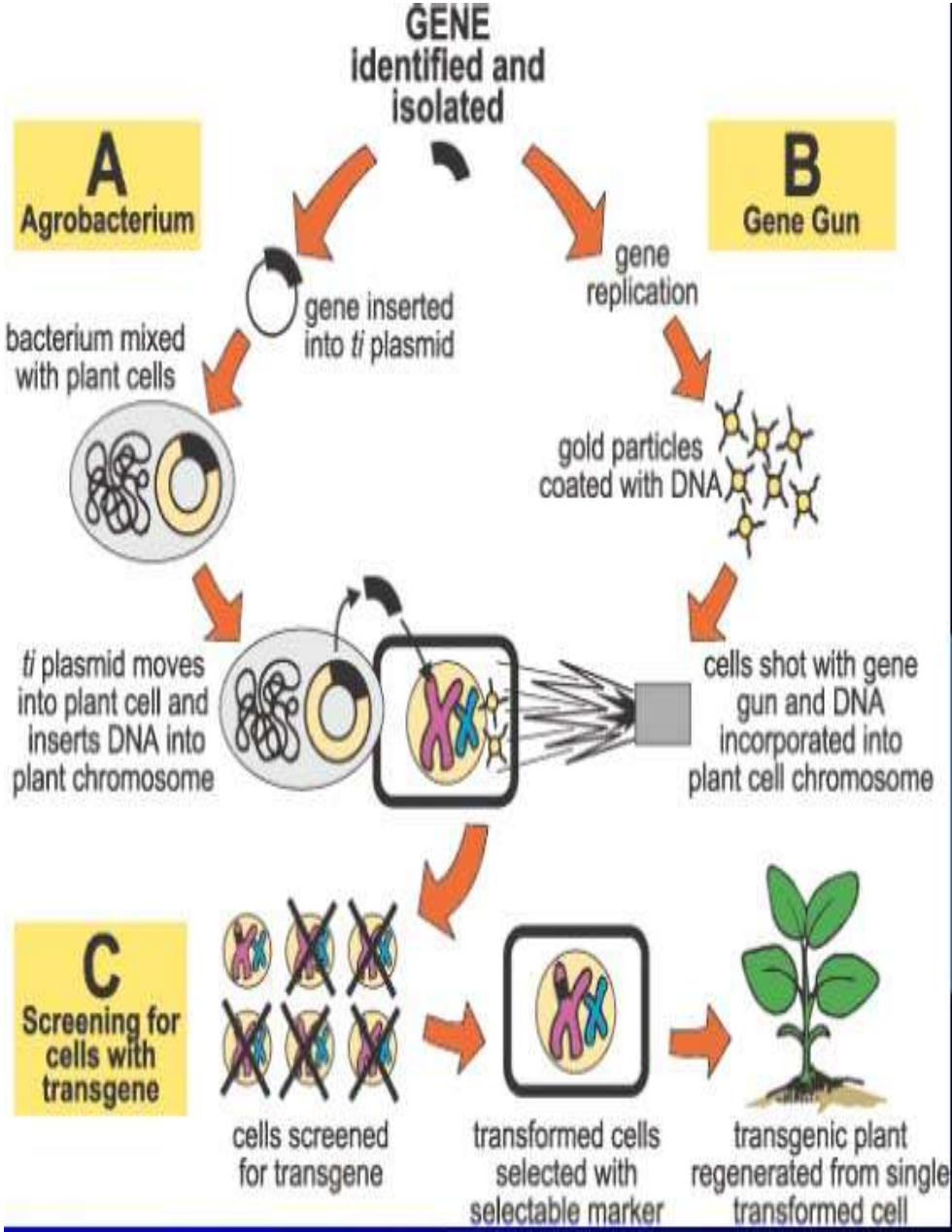


Transgenic Crops: Development Objectives

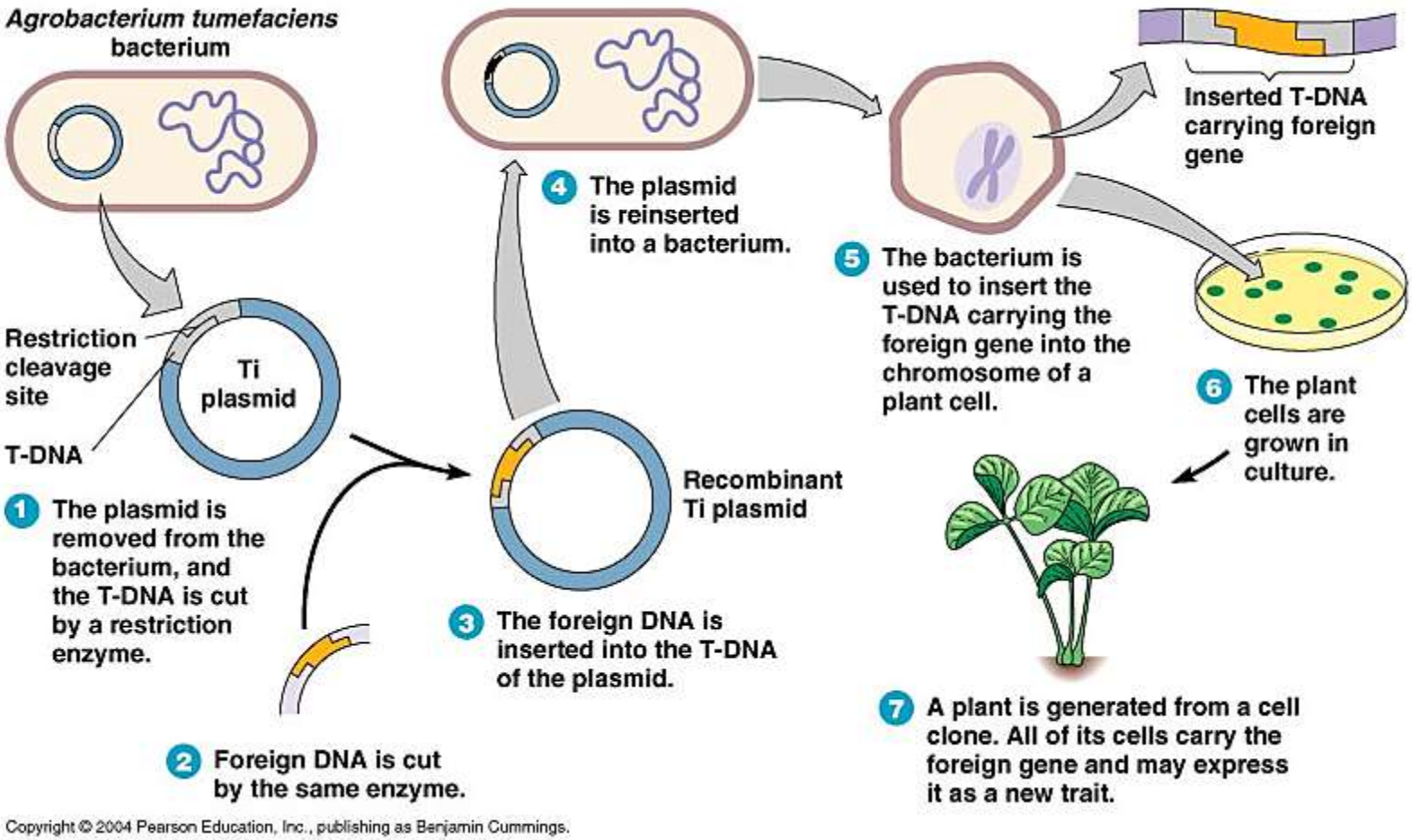
- Integrated pest management (IPM)
- Herbicide tolerance (HT)
- Nutritional enhancements
- Product quality improvement
- Increase in yield
- Stress tolerance (ST)
- Plant based pharmaceuticals

Development of GM Crop/Transgenic

- Identifying gene(s)
- Giving a desired trait
- Make copies of the gene
- Transfer to plant tissue
- Regenerate plants
- Lab analysis and safety testing
- Development of a variety
- Field tests
- Approval by Government agencies
- Monitoring of safety

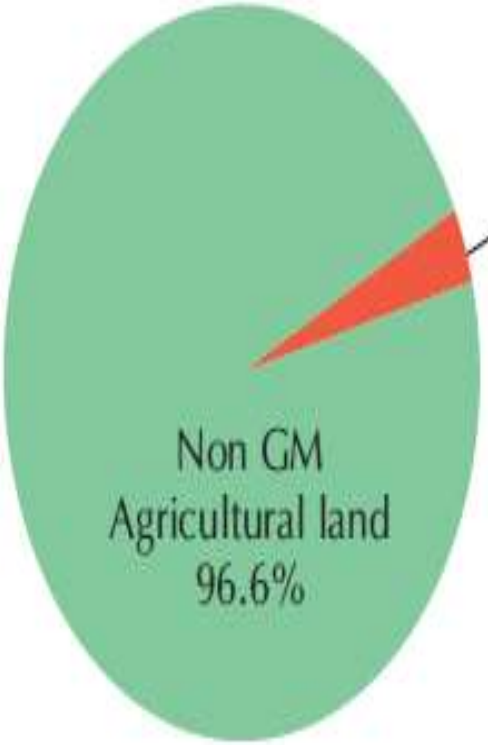


Produce Transgenic Plant



GLOBAL

World's total agricultural land under GM

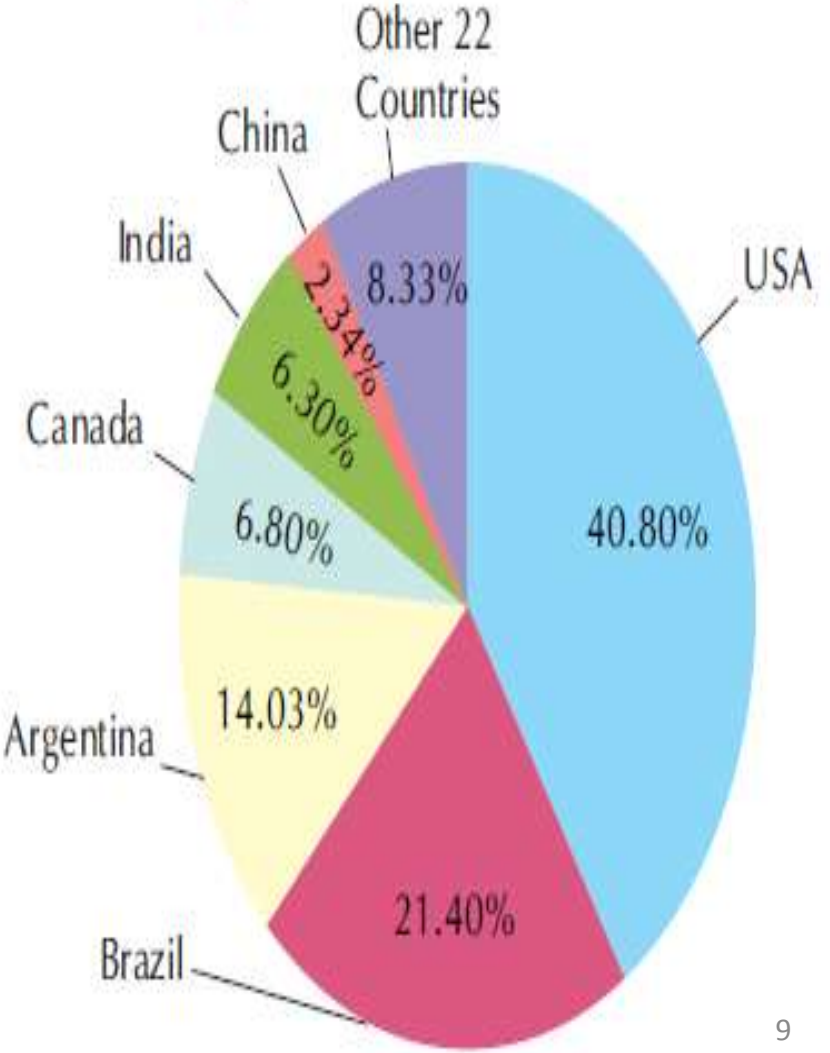


Total agricultural land in the world is 5.0 billion ha.

The area under GM crops is 170 million ha.

Percentage of agricultural land under GM 3.4%

Countrywise share of the world's 3.4% agricultural land under GM



Source: FAO Stat and ISAAA, 2013

What is Bt cotton ?

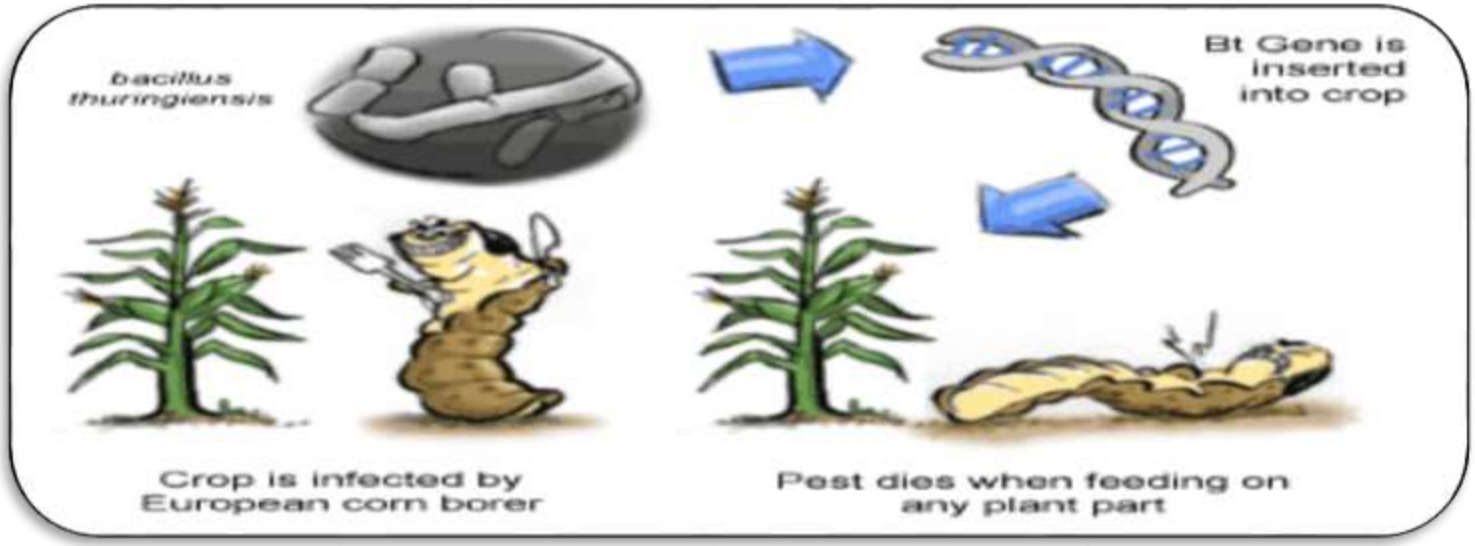
- Genetically modified variety of cotton that produces an insecticide.

What is Bt ?

- *Bacillus thuringiensis* discovered by Ishiwatari in 1901.
- Bacterium produces insecticidal crystal protein (ICP) also known As Cry protein
- They are a class of endotoxin – δ endotoxins.

How Bt works ?

1. Ingestion
2. Solublization & proteolytic activation
3. Binding to target site
4. Formation of toxic lesions



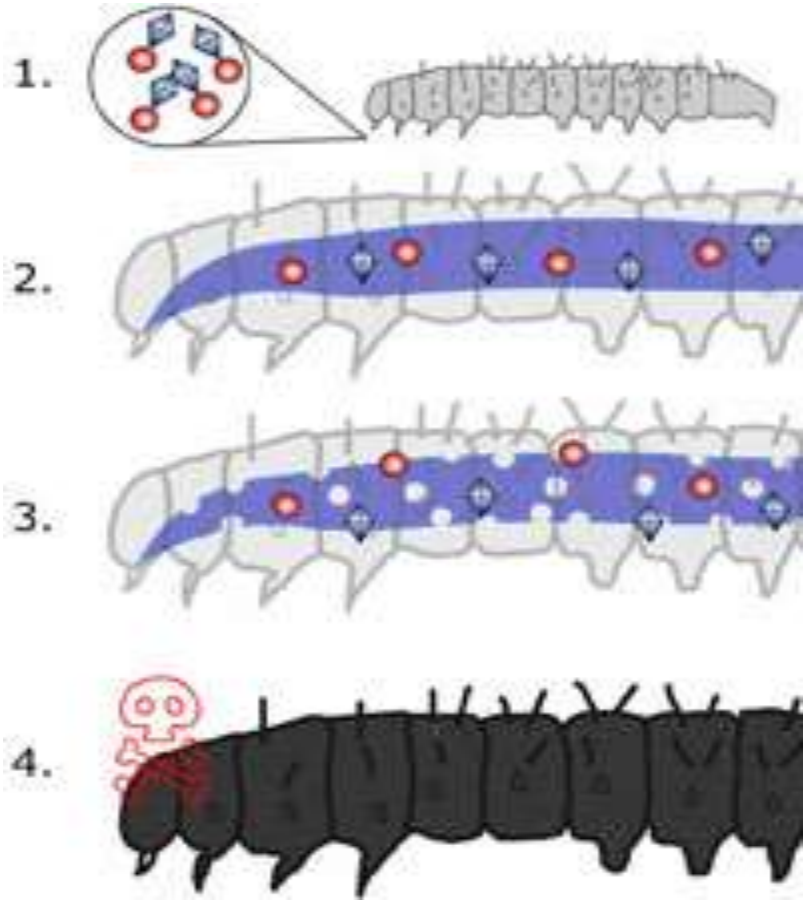
How Bt works ?

1. Insect eats *Bt* crystals and spores.

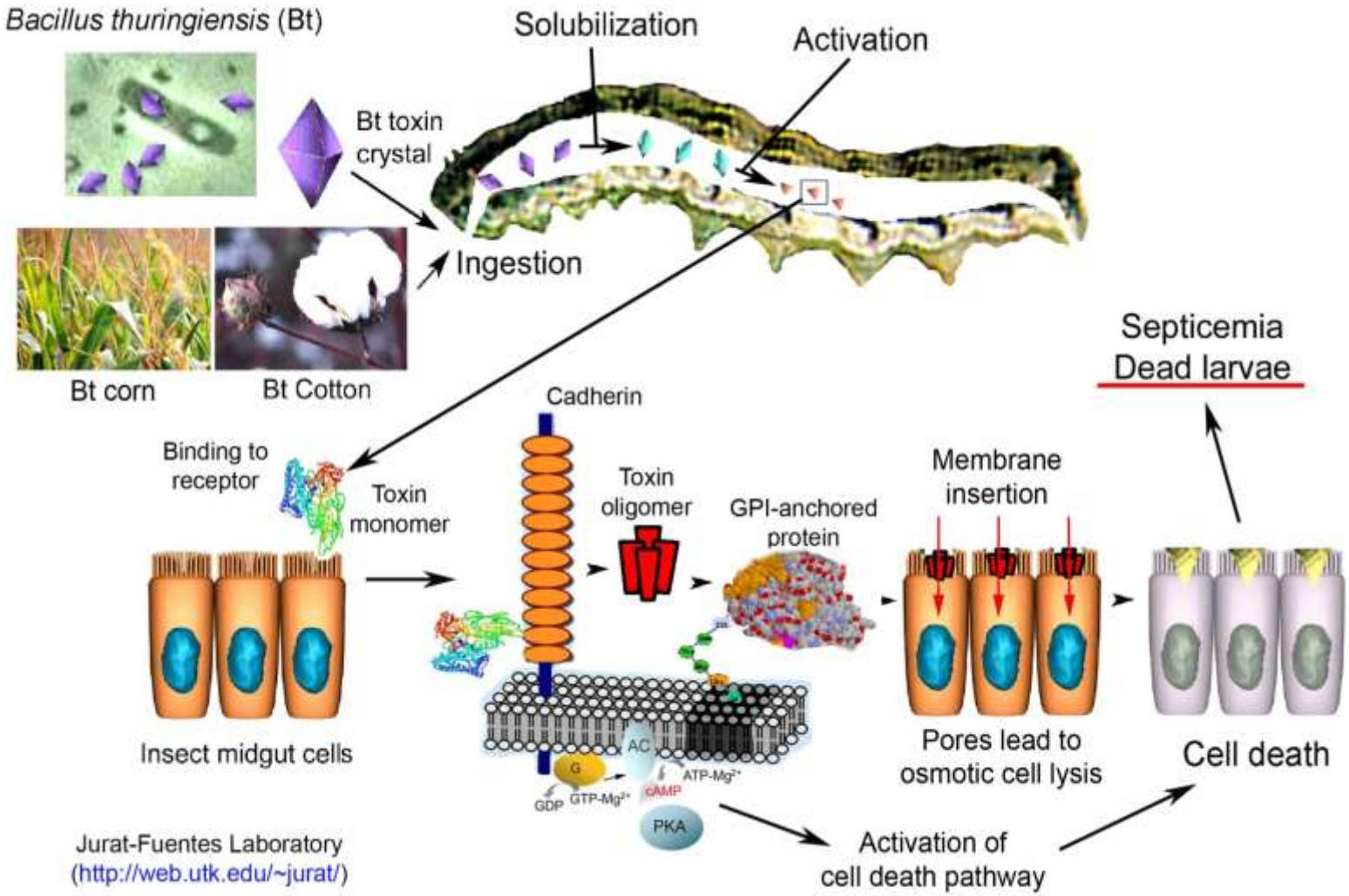
2. The toxin binds to specific receptors in the gut and the insects stops eating.

3. The crystals cause the gut wall to break down, allowing spores and normal gut bacteria to enter the body.

4. The insect dies as spores and gut bacteria proliferate in the body.



Mode of action of Cry toxin



GM crops-Pros

- Improved resistance to pests and diseases.
- Improved resistance to Herbicide
- Production of more nutritious staple crops
- Contribute to food security ,sustainability
- Contributing to the alleviation of poverty and hunger
- Increased crop productivity
- Stability of production
- Economic and social benefits

GM crops- Cons

- Human health
- Environmental hazards
- Effects on Non-Target organisms and plants

HUMAN HEALTH

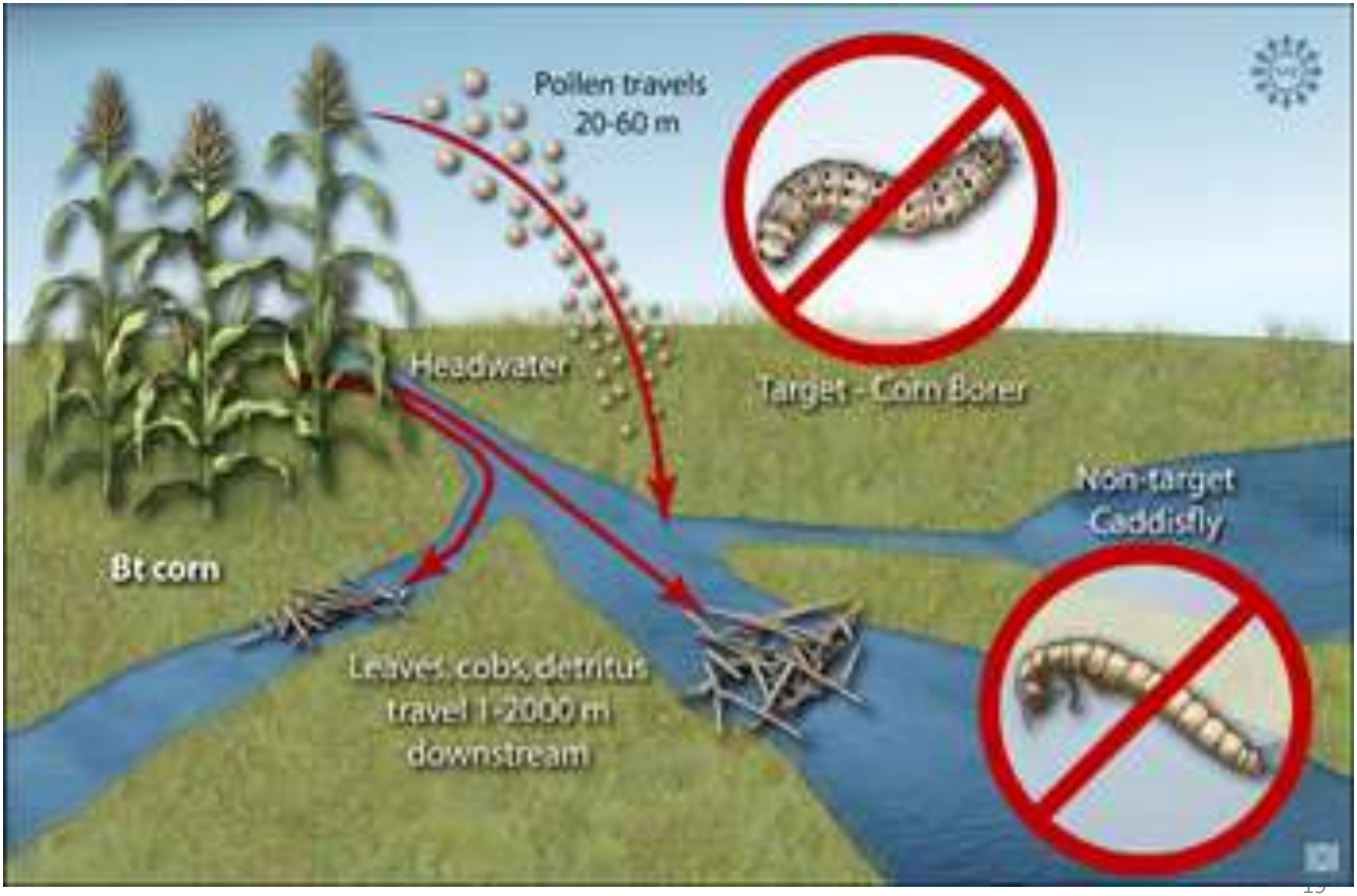
- Allergen and toxin

- Antibiotic resistance
- Unknown effects on human health

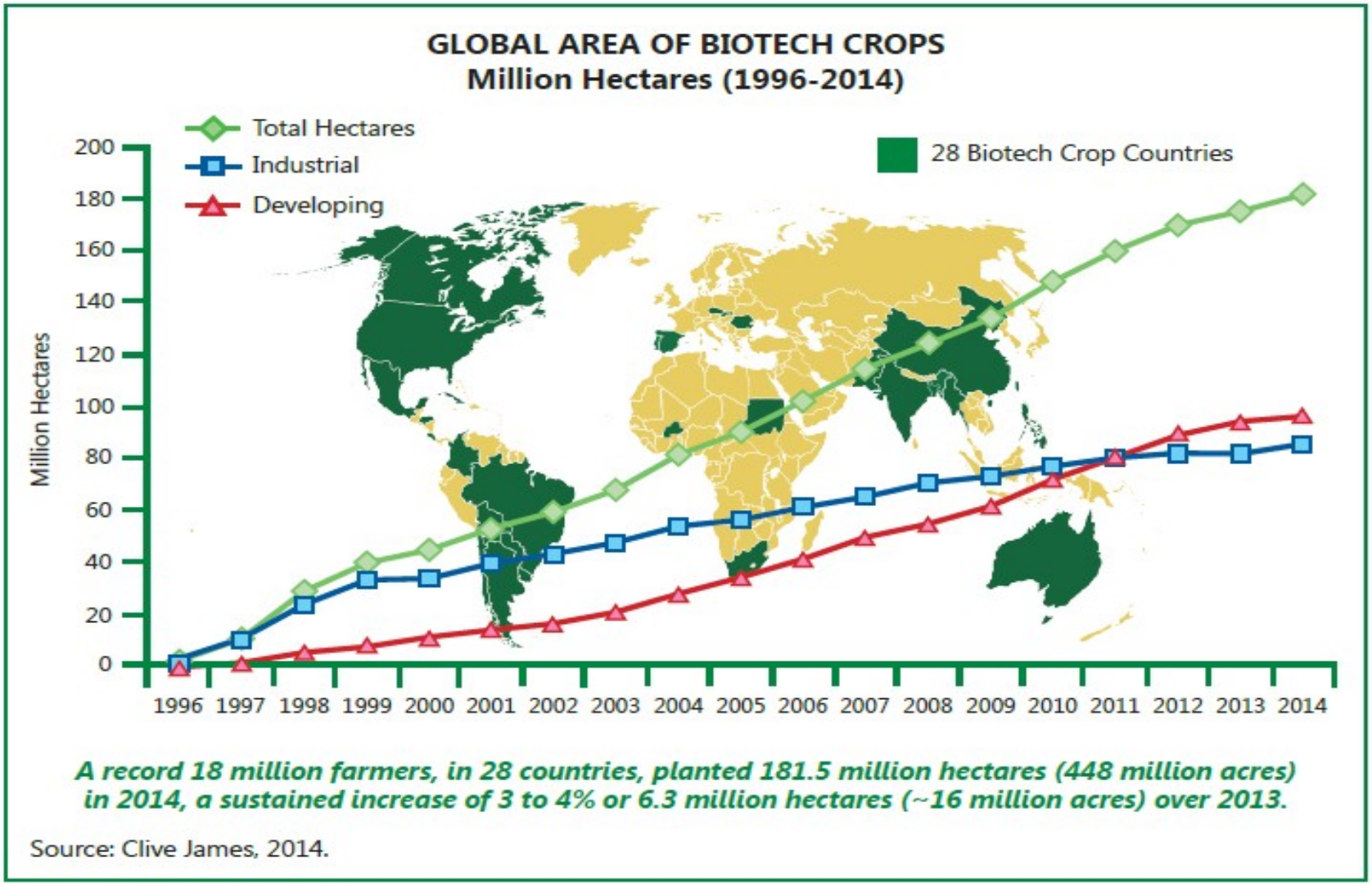
Environmental hazards

- Growing of GM crops may lead to monoculture
- The creation of pest or herbicide resistant GM crops could result in superbugs or super weeds

Effects on Non-Target organisms



Global Status of GM Foods



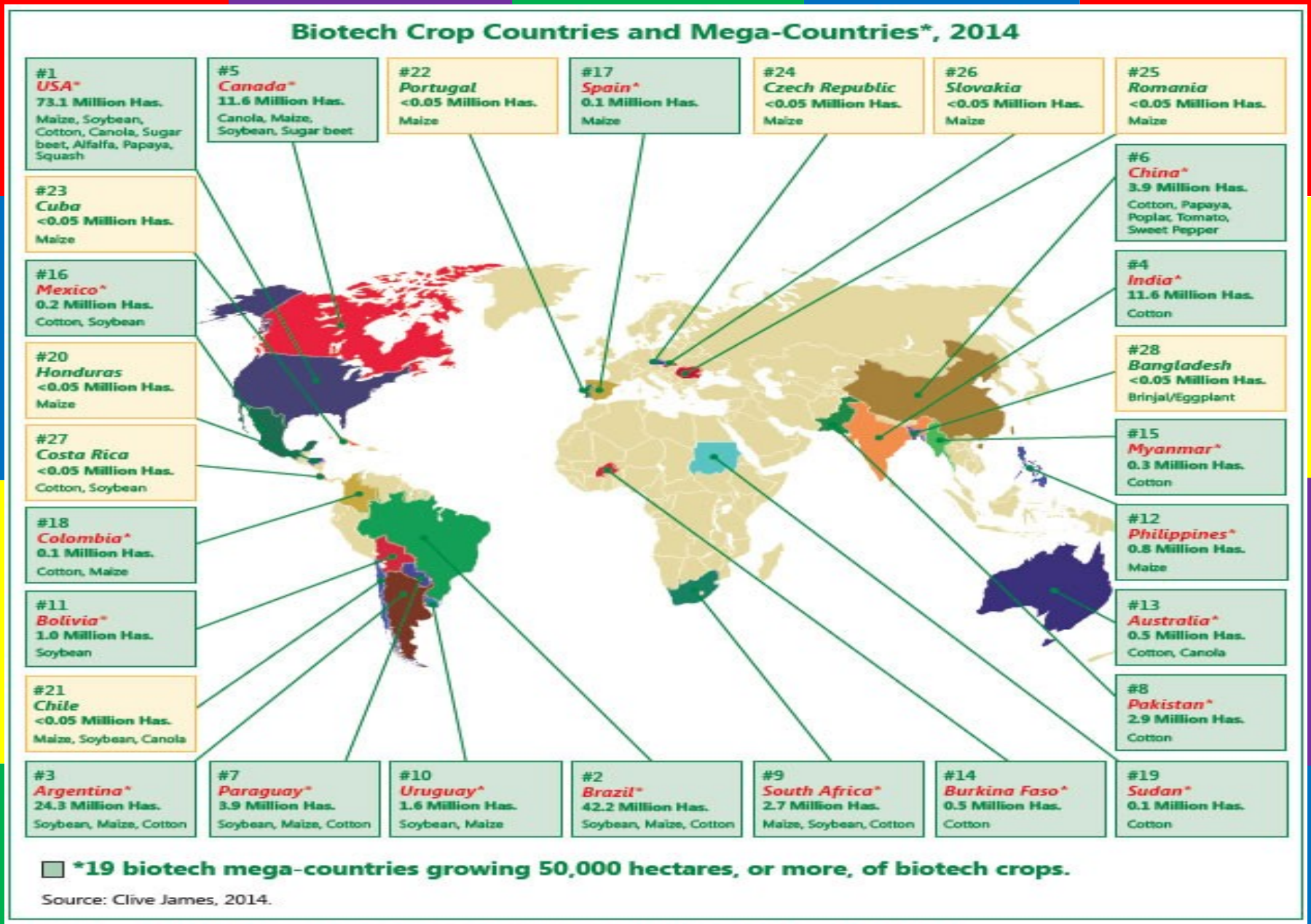


Figure 1. Global Map of Biotech Crop Countries and Mega-Countries in 2014

Rank	Country	Area (million hectares)	Biotech Crops
1	USA*	73.1	Maize, soybean, cotton, canola, sugar beet, alfalfa, papaya, squash
2	Brazil*	42.2	Soybean, maize, cotton
3	Argentina*	24.3	Soybean, maize, cotton
4	India*	11.6	Cotton
5	Canada*	11.6	Canola, maize, soybean, sugar beet
6	China*	3.9	Cotton, papaya, poplar, tomato, sweet pepper
7	Paraguay*	3.9	Soybean, maize cotton
8	Pakistan*	2.9	Cotton
9	South Africa*	2.7	Maize, soybean, cotton
10	Uruguay*	1.6	Soybean, maize
11	Bolivia*	1.0	Soybean
12	Philippines*	0.8	Maize
13	Australia*	0.5	Cotton, canola
14	Burkina Faso*	0.5	Cotton
15	Myanmar*	0.3	Cotton
16	Mexico*	0.2	Cotton, soybean
17	Spain*	0.1	Maize
18	Colombia*	0.1	Cotton, maize
19	Sudan*	0.1	Cotton
20	Honduras	<0.1	Maize
21	Chile	<0.1	Maize, soybean, canola
22	Portugal	<0.1	Maize
23	Cuba	<0.1	Maize
24	Czech Republic	<0.1	Maize
25	Romania	<0.1	Maize
26	Slovakia	<0.1	Maize
27	Costa Rica	<0.1	Cotton, soybean
28	Bangladesh	<0.1	Brinjal/Eggplant
	Total	**181.5**	

3. Third Generation

- These GM foods are in the research pipeline. These plants may have traits that can provide increased ability to resist abiotic stress such as drought, increased temperature or saline soils.

- Other traits may provide health benefits. Yet, another objective may be to create "pharmaplants" to help produce active pharmaceutical products.

- In February 2009, the U.S. Food and Drug Administration (FDA) approved the license for a recombinant anti-thrombin for prevention of blood clots in patients with hereditary anti-thrombin deficiency.

- Recombinant anti-thrombin is the first human biologic drug derived from the milk of goats that have been genetically engineered to produce human anti-thrombin in their milk.

GM Food Techniques

There are 3 main types of GM food technique:

1. Inserting genes (Gene Shifting):

- Genes are determined by different DNA sequences, when the isolated gene is inserted into a plant, it becomes part of the plant's gene and works with its own function .

- This method can increase or improve the plant such as resistance to insects, which increases the yield of food afterwards.

2. Removing genes (Gene Silencing):

- The function is reduced or stopped through genetic modification e.g. the function of virus which causes dried and spot of tomato is reduced by removing parts of the gene, thus the virus cannot be reproduced and tomato can grow healthily.

3. Changing the process of catabolism (Gene splicing):

- Food can be enhanced by changing the process of catabolism, such as controlling the percentage of starch of glutinous rice, and it also includes controlling the taste, mass, colour, and usefulness of food.

Common genetically modified foods

- **Soybean, Corn & sugar-beet:-** resistant to glyphosate by inserting herbicide resistant gene.
- **Cottonseed oil:-** by inserting pest resistant Bt crystal protein gene.
- **Tomato:-** by removing the gene that codes for polygalacturonase, responsible for softening of fruits after harvesting.
- **Potatoes:-** Amylopectin rich variety by switching off of GBSS (granule bound starch synthase) gene, responsible for amylose production.
- **Rapeseed (canola):-** with high oleic acid content by adding new gene.
- **Rice:-** with high Vitamin A by inserting gene from daffodils .

More Specific examples of GM foods

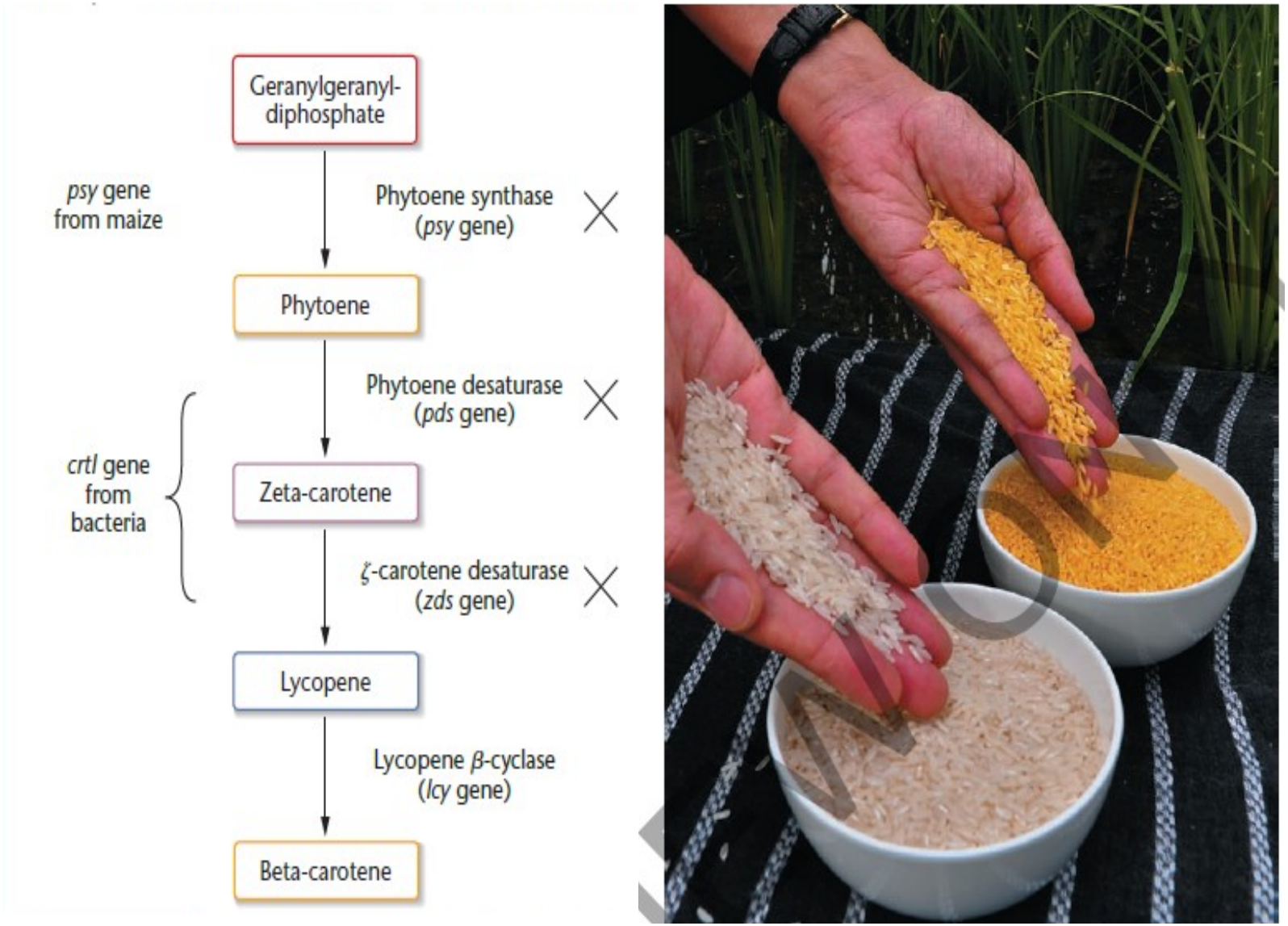
1) **Golden rice**

- It was created by Ingo Potrykus. Golden rice is a variety of rice produced through genetic modification to biosynthesize the precursors of beta-carotene (pro-vitamin A) in the edible parts of rice (endosperm).

- More than 120 million children in the world suffer from vitamin A deficiency. Golden rice has the potential to help prevent the 1 to 2 million deaths each year caused by a deficiency in this vitamin.

•Golden rice was created by incorporating rice with two beta carotene biosynthesis genes:

- Psy (Phytoene synthase)
- Lyc (lycopene cyclase)



Beta-carotene pathway in Golden Rice

2. Cold tolerant tomatoes

- Scientists have created a frost resistant tomato plant by adding an antifreeze gene from a cold water fish to it. The antifreeze genes come from the cold water flounder, a fish that can survive in very cold conditions.

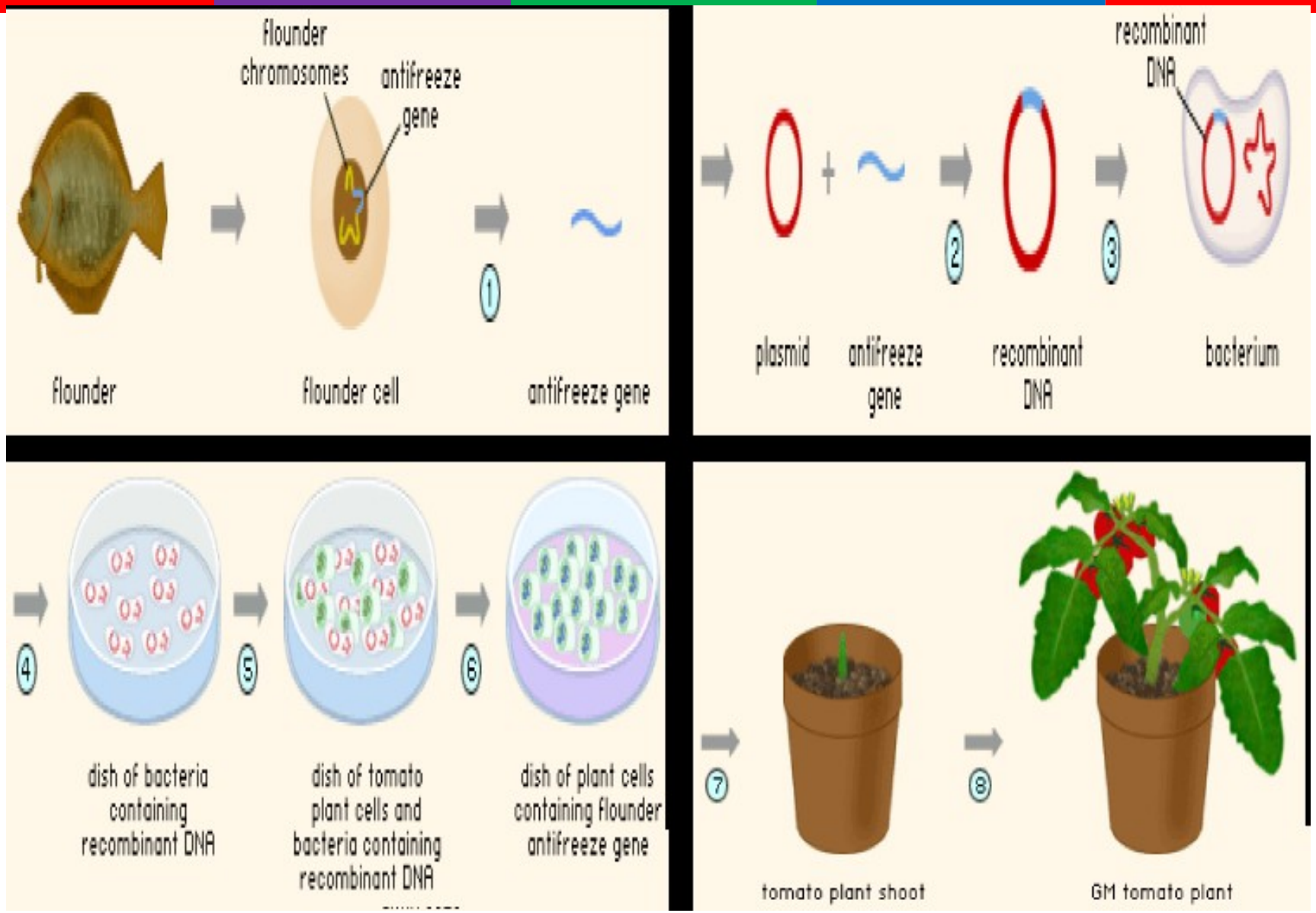
- The flounder has a gene to make chemical antifreeze. This is removed from the antifreeze DNA and is joined onto a piece of DNA called a plasmid. This hybrid DNA, which is a combination of DNA from two different sources, is known as recombinant DNA.

Cold water fish

+

Tomato

= **Frost resistant tomato**



Pathway for cold tolerant tomatoes using antifreeze gene

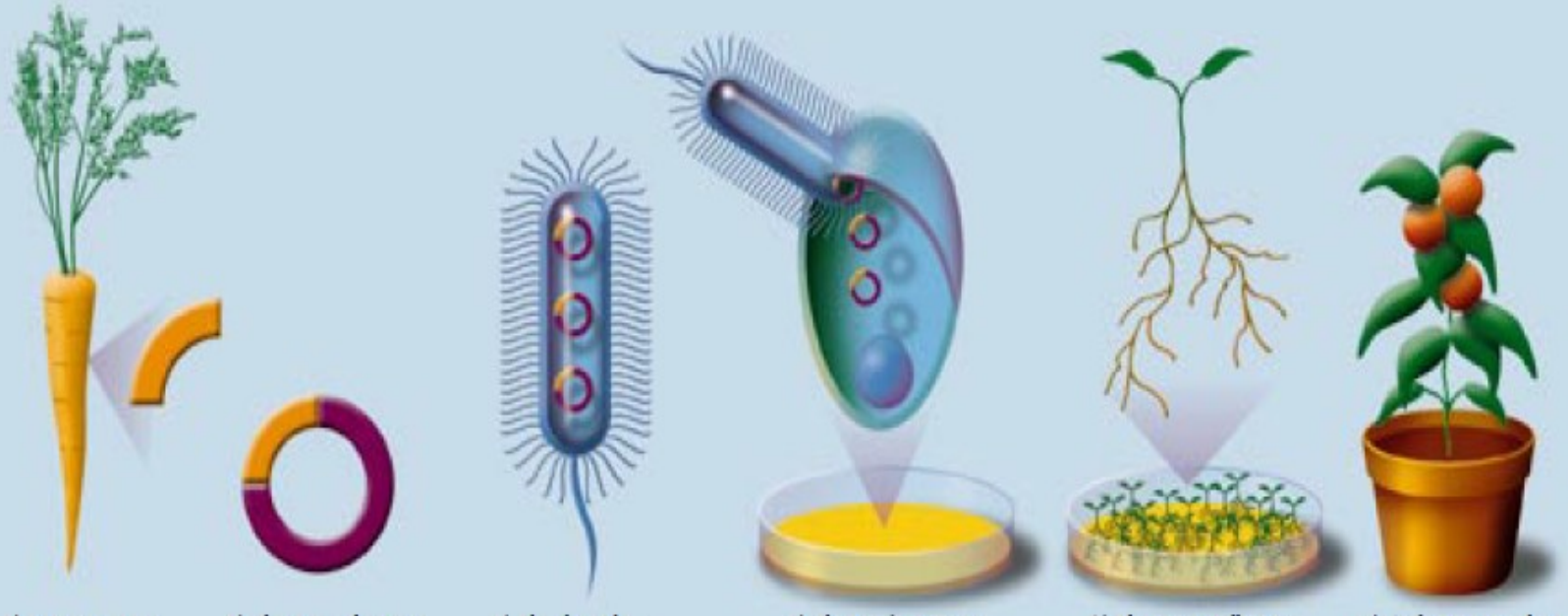
3. Vitamin rich tomatoes

- The *Agrobacterium* naturally infects plants by causing various diseases. By replacing that gene with desirable ones, results into the new genetic makeup with advantageous traits.

- The bright orange color of carrots comes from beta-carotene, which works as the precursor for the synthesis of vitamin A in our body. So by inserting this color gene into the tomato, enhance its appearance as well as its vitamin A level to the desired level.

Creating a Vitamin-Rich Tomato with a Carrot Gene

The bacterium Agrobacterium naturally infects plants. It carries some genes on a circular piece of DNA called a ***plasmid*** *and inserts those genes into plant cells. Scientists are now able to remove the bacterium's genes that cause plant disease and add a gene for a desirable trait.*



1) Scientists copy a carrot gene that converts a pigment to beta-carotene.

2) They insert the carrot gene into a plasmid.

3) The plasmid is reintroduced into the Agrobacterium.

4) The Agrobacterium transfers the carrot gene to the cells of tomato leaves in a petri dish.

5) The tomato cells grow and divide in a culture with hormones that encourage the cells to become new shoots and roots.

6) As the tiny new plants grow, the carrot gene converts the tomato's pigment into beta-carotene, creating an enhanced tomato.

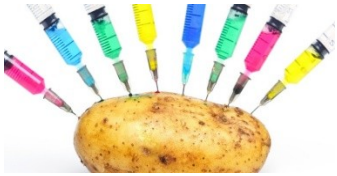
4) Protein enriched potatoes for NASA

- Potato is a non-cereal food crop limited in the amount of lysine, tyrosine, methionine and cysteine.

- To provide sufficient protein and amino acids to astronauts with their complete nutritional requirements, a tuber-specific protein amaranth seed albumin (AmA1) has been used to transform potatoes.

- The AmA1 protein has a well-balanced amino acid profile. In fact its amino acid composition exceeds values recommended by the W.H.O. for a nutritionally rich protein.

- This protein was used due to its non-allergenicity in its purified form. When the AmA1 gene was inserted into a potato, 2.5 to 4 fold increases in lysine, tyrosine, methionine and cysteine content and 35 to 45% increases in total protein content was reported in transgenic tubers.



5) Bt Soyabean

- The two target insects for insect-resistant, transgenic soybeans are the velvet bean caterpillar and the soybean looper.

- These pests feed on the leaves of the soybean plant and can severely limit yield. Velvet bean caterpillar populations can reach damaging levels rapidly. Many producers in areas where velvet bean caterpillar is a significant problem apply a preventive treatment of Dimilin when plants are in full bloom.

- Scientist have incorporated *Bacillus thuringiensis* gene into soybean which has insecticidal protein that maintains the yield of the crop. *Bacillus thuringiensis*, a ubiquitous soil bacterium is the source of the gene for insect resistance.

Infestation of a transgenic Bt soybean with velvet bean caterpillar. The non transgenic control on the right shows extensive defoliation.

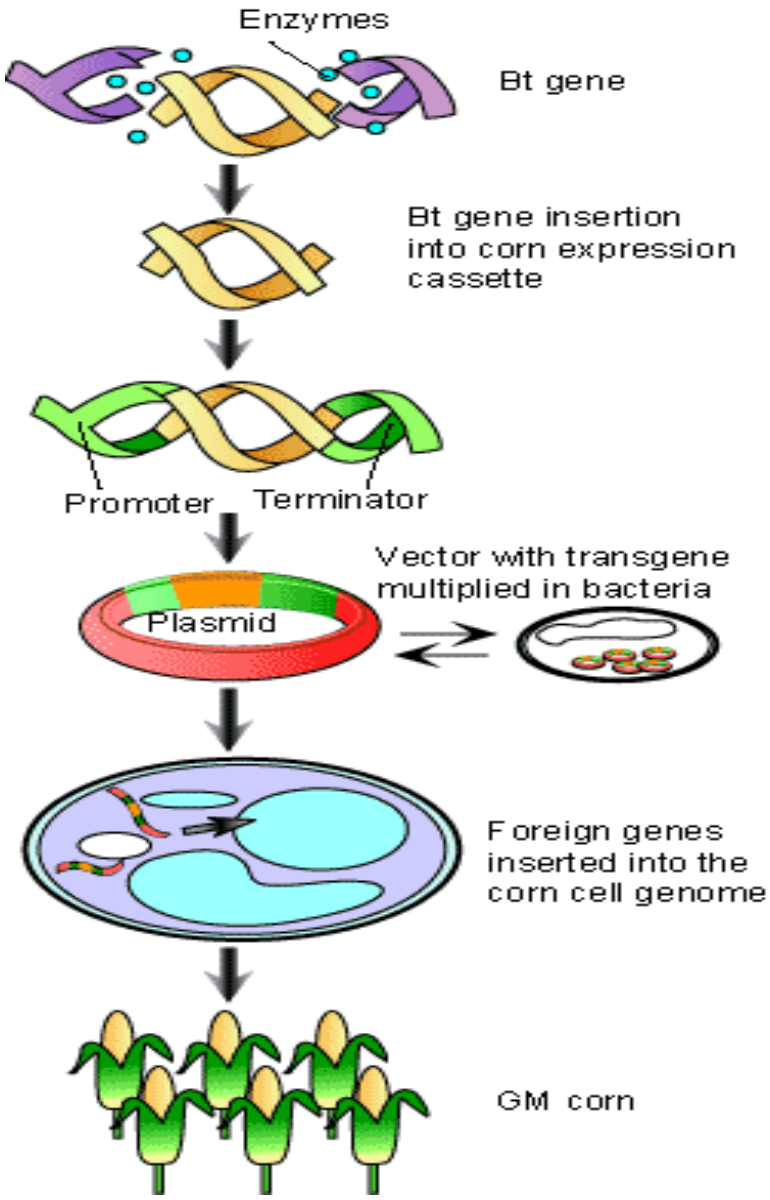
6) Genetically modified corn

- Corn has been deliberately genetically modified (GM) to have agronomically desirable traits.

- Traits that have been engineered into corn include resistance to herbicides and resistance to insect pests, the latter being achieved by incorporation of a gene that codes for the *Bacillus thuringiensis* (Bt) toxin.

- Corn varieties resistant to glyphosate herbicides (Liberty and Roundup) have been produced. Pioneer Hi-Bred has marketed corn hybrids with tolerance to imidazoline herbicides under the trademark "Clearfield".

Figure 12: Genetically modified maize (corn).



Flow chart for production of Bt Corn

7) Roundup Ready Soyabean

- The Roundup Ready soybean is a transgenic soybean that has been immunized to the Roundup herbicide. Since the soybean's natural trypsin inhibitors provide protection against pests, the only major problem in soybean farming was weeds, thus making soybean revolutionary.

- The glyphosate in the herbicide would inhibit the soybean plant's ESPSP gene, which is involved in the maintenance of the "biosynthesis of aromatic metabolites," and cause the plant to die along with the weeds for which the herbicide was meant.

- A plasmid which was transferred to the soybean cells through the cauliflower mosaic virus was soon developed to provide immunity to glyphosate-containing herbicides, and, after this process was perfected, the Roundup Ready soybean was ready, first hitting the US market in 1996 (Neil *et al.,* 2000).

8. Canola oil

- Rapeseed oil had a distinctive taste and a disagreeable greenish color due to the presence of chlorophyll. It also contains a high concentration of erucic acid.

- Experiments on animals have pointed to the possibility that erucic acid, consumed in large quantities, may cause heart damage.

- A known toxin, the cultivar used to produce commercial food-grade canola oil was bred to contain less than 2% erucic acid, levels that are not believed to cause harm in humans and no ill health effects has been associated with consumption by humans of the genetically modified oil (Harvey and Downey, 2003).

9. Papaya

- Papaya cultivation is threatened by papaya ring spot virus, a disease that sharply lowers the fruit yield.

- The University of Hawaii developed a ring spot virus disease resistant papaya. To do this, certain viral genes encoding capsid proteins were transferred to the papaya genome.

- These viral capsid proteins elicit something similar to an “immune response” from the papaya plant. The first resistant papaya varieties were grown commercially in 1999 in Hawaii. These genetically modified papayas are approved for consumption both in US and in Canada (Nap *et al.,* 2003).

Food Companies Using Monsanto's Products: (In Alphabetic Order...)

Aunt Jemima
Aurora Foods
Banquet
Best foods
Betty Crocker
Bisquick
Cadbury
Campbell's
Capri-sun
Carnation
Chef Boyardee
Coca Cola
ConAgra
Cool-aid
Delicious brand cookies
Famous Amos
Flowers industries
Frito-lay
General Mills
Green Giant
Healthy Choice
Heinz
Hellmans
Holsum
Hormel
Hungry Jack
Hunts
Interstate Bakeries
Jiffy
KC Masterpiece
Keebler Industries
Kellogs
Kid Cuisine
Knorr
Kraft
Lean Cuisine
Lipton
Loma Linda
Marie Callenders
Minute Made
Morningstar
Ms. Butterworths
Nabisco
Nature Valley
Ocean Spray
Ore-Ida
Orville Redenbacher
Pasta-roni
Peppridge farms
Pepsi
Phillip Morris
Pop Secret
Post Cereals
Power Bar Brand
Prego Pasta Sauce
Pringles
Procter & Gamble
Quaker
Ragu sauce
Rice-a-roni
Smart Ones
Stouffers
Sweppes
Tombstone Pizza
Totinos
Uncle Ben's
Unilever
V-8

#MAM


Kellogg's
CORN POPS
Kellogg's
ALL-BRAN
Crispix
Kellogg's
APPLE JACKS
Carr's
Fruity Snacks
Chips Deluxe COOKIES
Müeslix
cereal
Austin
• SINCE 1932 •
MorningStar FARMS
Mother's Cookies
Famous Amos
Kellogg's
Cracklin' Oat Bran
CORN FLAKES
CRUNCH MANIA
Kashi
Gardenburger
BOYCOTT
KELLOGG'S
Special K
Pringles
Keebler
Kellogg's
CRUNCHY NUT
MURRAY
Sugar Free COOKIES
Sign the petition
asking them to
remove GMOs!
CHEEZ-IT
Kellogg's
Eggo
pop-tarts
GMO FREE USA
GMO FREE CANADA
Kellogg's
CINNABON
PRODUCT 19
FROOT LOOPS
Kellogg's
SMART START
CEREAL
TOWN HOUSE
Kellogg's
RICE KRISPIES
Worthington
SMORZ
Kellogg's
Raisin Bran
Kellogg's
FiberPlus
Kellogg's
FROSTED FLAKES
Kellogg's
HONEY SMACKS
Kellogg's
KrAVe
Kellogg's
LOW FAT Granola
ORIGINAL
Kellogg's
FiberPlus
Antioxidants
Nutri-Grain

Health and Safety Concerns of GM Foods for Human Consumption

The WHO has identified the following issues of concern for human health with respect to genetically modified foods:

1)Allergenicity:

•GM foods have the potential to cause allergic reactions in general; this risk is comparable to the risks associated with traditionally grown foods.

•However, the proteins produced by any newly introduced genes have the potential to cause an additional allergic response (USDA, 2013).

•To prevent such allergenicity, the transfer of genes from commonly allergenic foods is discouraged unless it can be proven that the protein produced by the introduced gene will not be allergenic (WHO, 2013).

•Another potential risk is the introduction of an entirely new protein that did not previously exist in the food chain.

Contd….

2) Gene Transfer

•Another potential concern arising from GE foods is the transfer of genetic material from GE foods to the cells of the human body or the bacteria in the intestinal tract.

•DNA from ingested food is not completely degraded by digestion and small fragments of DNA from GM foods, have been found in different parts of the gastrointestinal tract.

•This could result in horizontal gene transfer due to absorption of DNA fragments by gut microflora or somatic cells lining the intestinal cells.

•Scientists however, have postulated that uptake of GM DNA into the cells of the gastrointestinal tract will not have any biological consequences because this DNA will be degraded in the cells.

Contd….

3) Increase in Anti-nutrients

- Anti-nutrients are substances that interfere with the utilization of nutrients.

- The insertion of a new gene may lead to an increase in the existing levels of anti-nutrients.

- For example, glyphosate resistant Roundup Ready soybean has been shown to increase anti-nutrients.

- In sheep and cattle, heat-stable anti-nutrients such as phytoestrogens, glucinins, and phytic acid have been found to cause infertility, allergic reactions, and decreased availability of phosphorus and zinc, respectively (Dona and Arvanitoyannis, 2009).

Governments and GM Foods

- **Europe:** Anti-GM protests (Austria, France, Hungary)
- **Japan:** GM testing is mandatory. Customers for organic
- **USA:** FDA → GM foods are substantially equivalent to natural food, so not subject to FDA regulations
  GRAS → Generally Recognized As Safe
- **India:** No policy yet → for GM → ↓ poverty
- **Brazil:** Some states have banned GM crops
  Smuggle to compete with grain-exporting countries.
- **Africa:** EU opposes the use of GM in Africa
  S. Africa, Sudan, Zimbabwe have GM laws; Kenya Act → 2009
- **Argentina:** Very pro-GM
- **New Zealand:** NO GM Foods grown here!

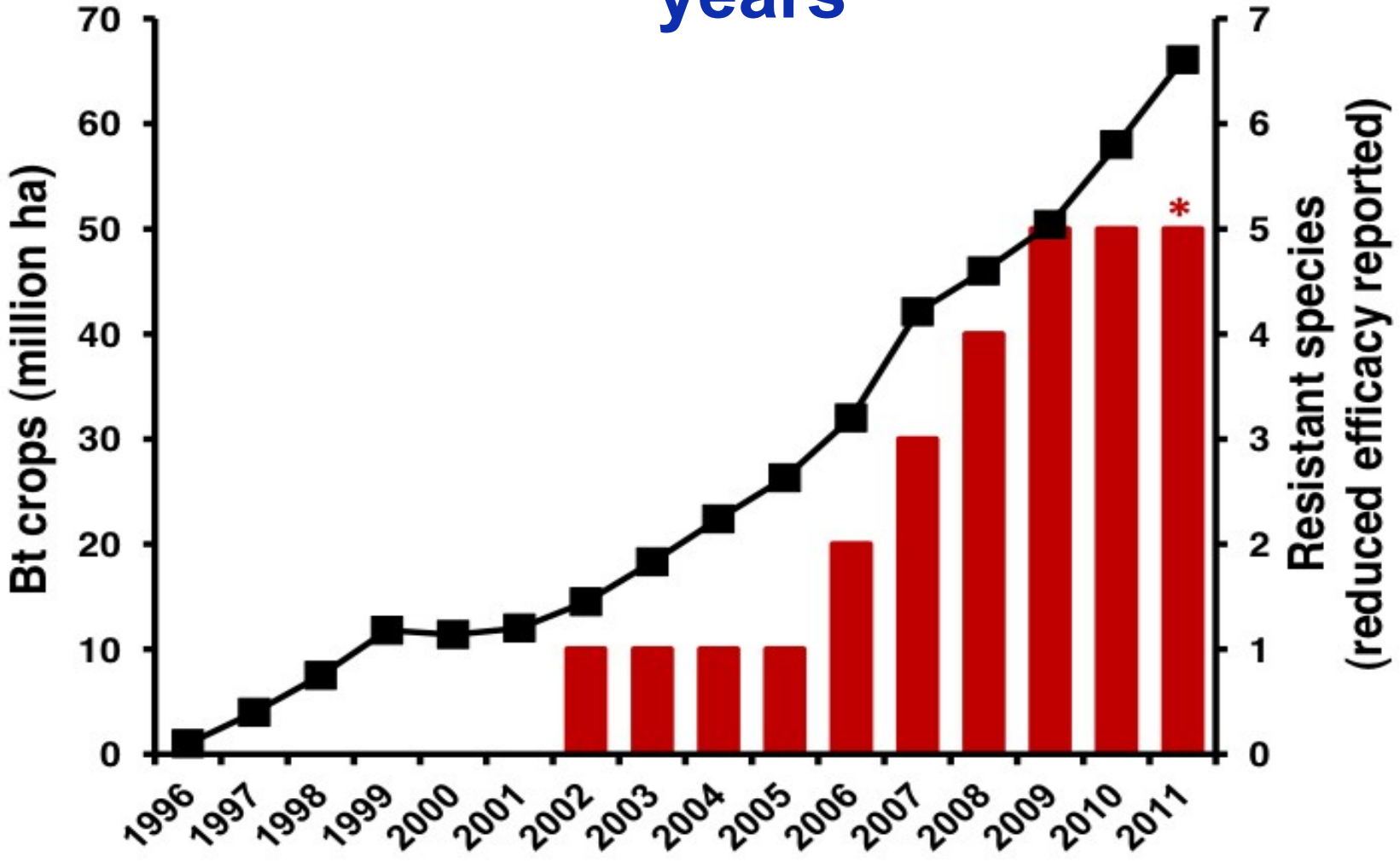
Current Status of GM Food in India

- India is a signatory to the Cartagena Protocol on Biosafety (CPB) since 2003.

- India's apex biotech regulatory committee, the Genetic Engineering Approval Committee (GEAC) that functions as a statutory body under the Environment Protection Act 1986 of the Ministry of Environment & Forests (MoEF), has been changed to Genetic Engineering Appraisal Committee in July 22, 2010.

Bt Cotton is the only GM crop grown in India

Bt Cotton production in India over the years



Pros of genetically modified foods ?

- Improved yield
- More resistant to disease
- Less likely to be damaged by insect
- Tolerance to herbicides
- Better nutritional value
- Increased shelf life
- Improvement in health and environment
- Better climatic survival by increasing tolerance to draught, flood or frosty conditions to allow the use of previously inhospitable land
- Higher crop yields
- Reduced farm costs
- Increased farm profit

- Tolerent / resistance crops (Pests, Diseases, Drought, Frost, Flood)

Increased nutrition

Edible vaccines

More food

Cheaper food

Reduced risk

Reducing world hunger and improving world health

Why Produce GM Food?

- Traditionally, combining the desirable genes in one plant is a tough task that utilizes longer time and so much attention, involving crossing one plant to another plant of the same species or related species.

- From economical and agricultural standpoints, it is advantageous to grow crops that have higher yield or improved quality, pest or disease resistance, or tolerance to heat, cold and drought.

- Desirable genes may provide means for plants to combat these conditions.

- The development of transgenic technology allows useful genes from various living sources to be brought together in a relatively simple manner.

Trait	Advantage	Sample Product
Pest-Resistance	Less damage by insect, virus, bacteria, etc.	Corn
Herbicide-Resistance	Hebicides will kill only weeds, not crops	Cotton
Delayed Ripening	Can be shipped with less damage	Tomato
Miniature Size	Improved eating quality	Watermelon
Improved Sweetness	Better tasting	Sweet peas
Cold-Resistance	Withstands freezing and thawing	Strawberries
High Starch	Absorbs less oil when fried	Potato
Polyester Gene Added	Better fiber properties	Cotton
Growth Hormone Added	Faster growth	Salmon
Hepatitis B Virus Protein Added	May provide immunity to Hepatitis	Banana

Critism of GM Foods

1) Environmental hazards

- Unintended harm to other organism
  - Difficult to design toxin → kills crop-damaging pests, not other insects
- Reduced effectiveness of pesticides
  - Develops resistance → DDT
- Gene transfer to non-target species
  - Cross-breeding
  - Transfer of herbicide resistance from crops to weeds
  - The "superweeds" will then have herbicide tolerance as well

- **Solution**
  - Create buffer zone

2) Human health risks

- Allergenicity: We already have allergies to peanuts and other foods. Introducing gene may create more allergies.
- Unknown effects on human health
- However, proposal to introduce a gene from Brazil nuts into Soyabeans was abandoned.

On the whole, with the exception of possible allergenicity, scientists believe that GM foods do not present a risk to human health!

3) Economic concerns

- Lengthy and costly process
- May be patented
  - Monsanto, Novartis, Dow, DuPont hold patents for GM crops
  - Make substantial profit by exporting it to Ems'.
- Farmers from developing countries/EM cannot afford.
- More gap between rich and poor

4) Other invention → discouraged/stopped

- Suicide gene technology
  - Only one growing per season
  - Next time would produce sterile seeds that do not germinate.

Future of GM Foods

- GM advocates are confident that the next generation of GM foods will show even more promising prospects—and may also address many of the problems.

- Australian scientists are adding genes to bananas that will not only provide resistance to Panama disease, a serious fungal disease that can destroy crops but also increase the levels of beta-carotene and other nutrients, including iron.

- Other GM crops in the pipeline include plants engineered to resist drought, high salinity, nitrogen starvation, and low temperatures.

- The current techniques that researchers use to introduce genes into plant cells result in random insertions into the genome. New techniques are being devised that will allow genes to be inserted into precise locations in the genome, avoiding some of the potential unknown effects of disrupting a plant's normal genome with random integrations.

Contd….

- In the future, GM foods will likely include additional GM animals e.g. a transgenic Atlantic salmon variety is likely to receive marketing approval in the near future.
- In another project, scientists have introduced a DNA sequence into chickens that protects the birds from spreading avian influenza.
- Although these and other GM foods show promise for increasing agricultural productivity and decreasing disease, the political pressure from anti-GM critics remains a powerful force.
- An understanding of the science behind these technologies will help us all to evaluate the future of GM foods.

Conclusion

- Genetically modified food is still a new concern in few countries and its acceptance restricted mainly due to the mis and myth conceptions ignoring valuable benefits.

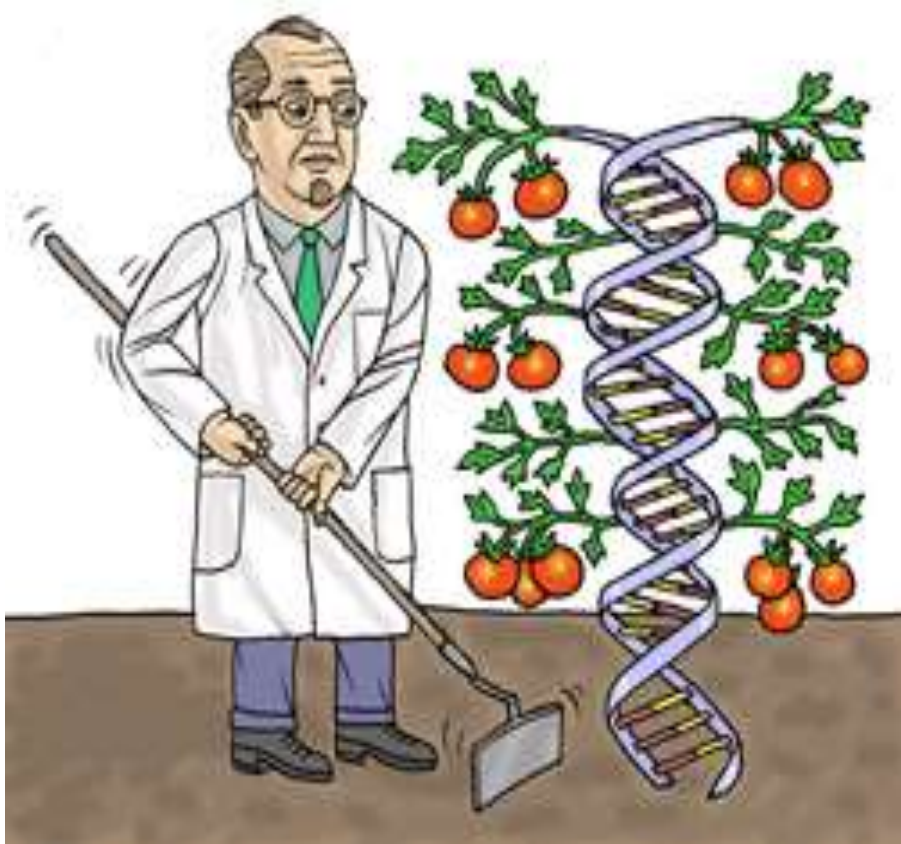
- India is the second most populated country, so to feed the large hungry and malnourished population is also a challenge.

- GM crop propagation proves to be a good alternate for revenue generation in the form of high yield, nutritious grain with less reliance on pesticides and herbicide which has no threat to our agriculture and environment.

- Despite all these positive attributes this technology still lies in its embryonic stage. Awareness programmes at village level for farmers to adopt newest technologies in field farming viz. crop rotation, organic farming and genetic modification results in increase in production per area with healthy crop.

Social Concern

- Health Risks
- Environment
- Labeling GM food
- Economical issues



Health Risks: Animals

- Many scientific data indicate that animals fed by GM crops have been harmed. E.g. rats exposed to GM potatoes and soya had abnormal young sperm.
- Cow, goats buffalo, pigs & other livestock grazing on Bt-maize & certain biotech corn showed complications including early delivery, abortions, infertility & many more died.

Health Risks: Human

- Many companies do not accept the direct link between GMF consumption & human health problems.
- E.g. Foodborne diseases such as soya allergies have increased over past 10 years in UK & USA.
- Many villagers & cotton handlers have developed skin allergies in India.

Environmental Risk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Thursday, 20 May, 1999, 12:47 GMT 13:47 UK

GM pollen 'can kill butterflies'

The monarch caterpillars feed on the milkweed plant

By Environment Correspondent Alex Kirby

Pollen from one of the most successful genetically modified (GM) crops in the US can kill the larvae of monarch butterflies, scientists say.

• The BBC's Robert Pigott
A setback for the biotechnology industry
real 28k

• John Losey
We need to make ...dgements ...d on good

- Genes may escape & find their way into other members of species or other species. Imagine the trouble if herbicide-resistant genes found their way into weeds.
- GM crops could compete or breed with wild species threatening biodiversity.
- Monogenetic crops may not react sufficiently to environmental stresses, posing danger of reenactment of Ireland's potato famine.
- Unintended harm to other species.

GM Labeling

- A proper labeling represents the “GM” word along with additional information on changed characteristics & the external source of the inserted genes.
- Why is it necessary to label GM food?

It is not about health issue rather, it is about consumer rights to make an informed choice on GM.

Economical Issues

- Risk of patent enforcement which may oblige farmers may to depend on giant engineering companies such as Monsanto for strains when their crops are pollinated.
- Patenting new plant varieties will raise the price of seeds so high that small farmers will not be able to afford seeds for GM crops, thus widening the gap between the wealthy and poor.

GMO And Ethical Issues

- Genetic modification of organisms can have unpredictable results when such organisms are introduced into the ecosystem. Therefore, the Indian Government has set up organizations such as **GEAC (Genetic Engineering Approval Committee),** which will make decisions regarding the validity of GM research and the safety of introducing GM-organisms for public services.
- The modification/usage of living organisms for public services (as food and medicine sources, for example) has also created problems with patents granted for the same.
- There is growing public anger that certain companies are being granted patents for products and technologies that make use of the genetic materials, plants and other biological resources that have long been identified, developed and used by farmers and indigenous people of a specific region/country.

GMO & Ethical Issues

- Biopiracy is the term used to refer to the use of bio-resources by multinational companies and other organizations without proper authorization from the countries and people concerned without compensatory payment.
- Most of the industrialized nations are rich financially but poor in biodiversity and traditional knowledge. In contrast the developing and the underdeveloped world is rich in biodiversity and traditional knowledge related to bio-resources.
- Traditional knowledge related to bio-resources can be exploited to develop modern applications and can also be used to save time, effort and expenditure during their

GMO & Ethical Issues

- There has been growing realization of the injustice, inadequate compensation and benefit sharing between developed and developing countries. Therefore, some nations are developing laws to prevent such unauthorized exploitation of their bio-resources and traditional knowledge.
- The Indian Parliament has recently cleared the second amendment of the Indian Patents Bill, that takes such issues into consideration, including patent terms emergency provisions and research and development initiative.