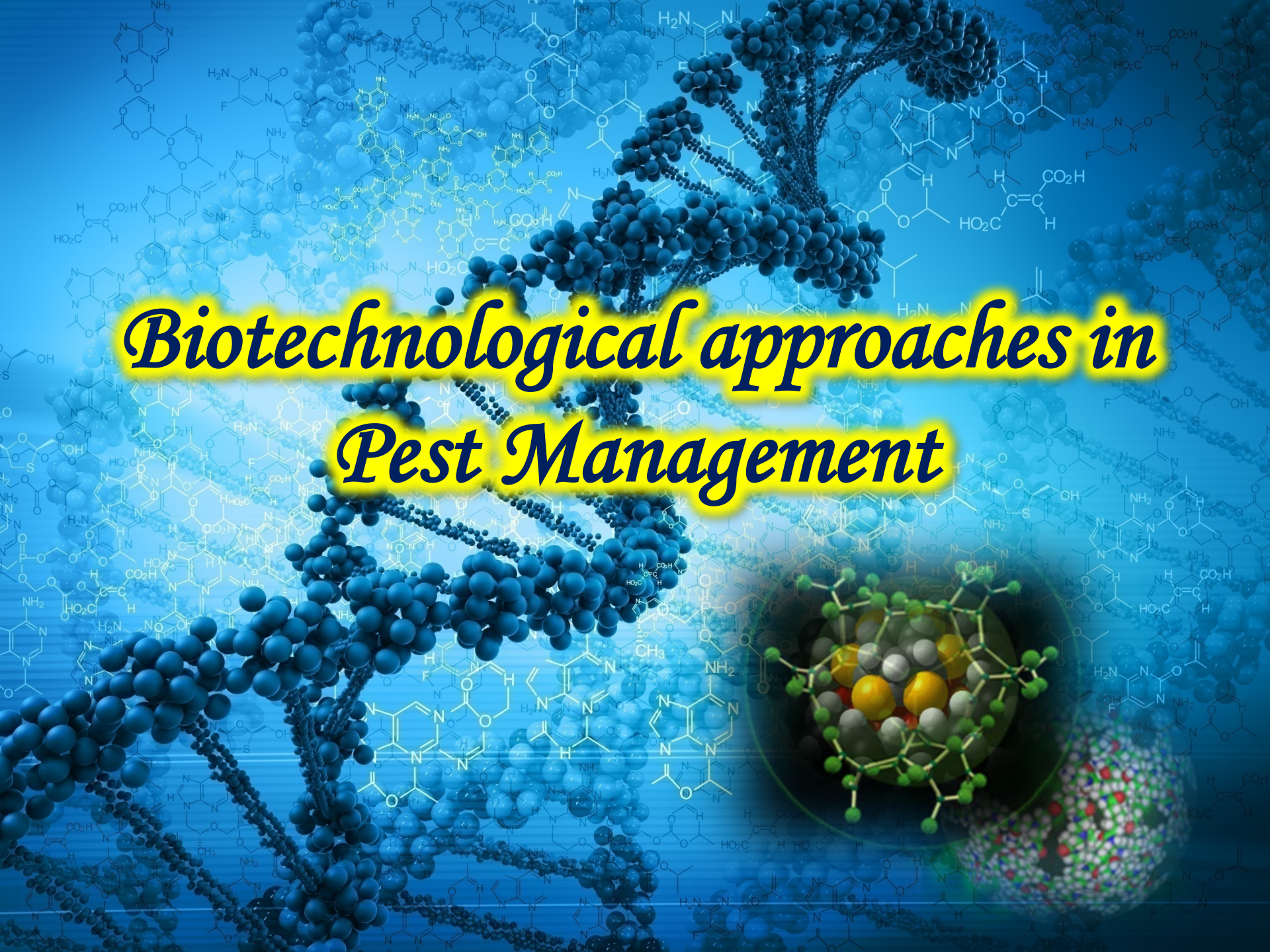
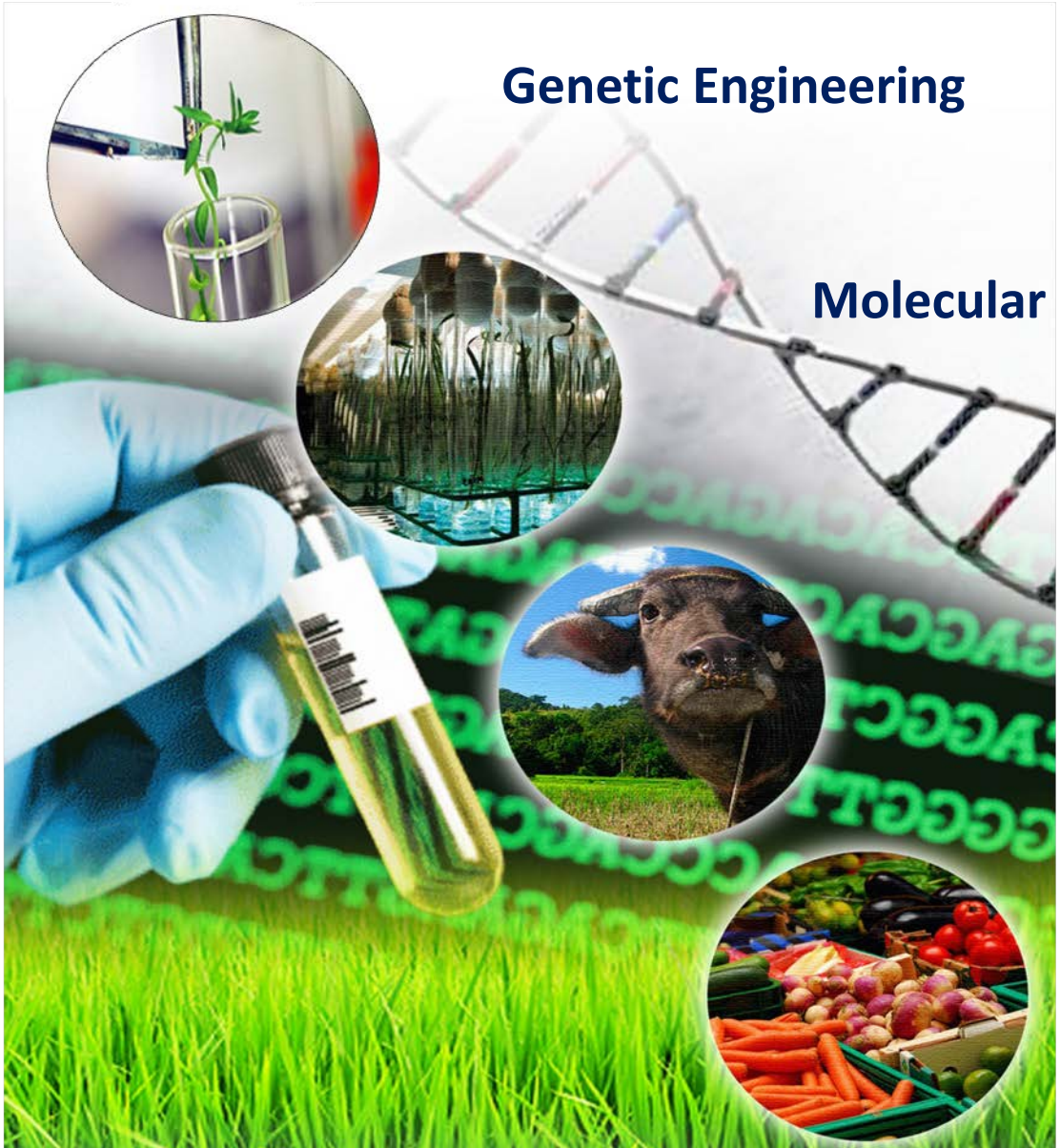

Biotechnological approaches in
Pest Management

Biotechnology in Agriculture?

Any technique that uses living organisms or substances from these organisms, to make or modify a product, to improve plants or animals or to develop substance for specific uses.

How is Agricultural Biotechnology used?



Genetic Engineering

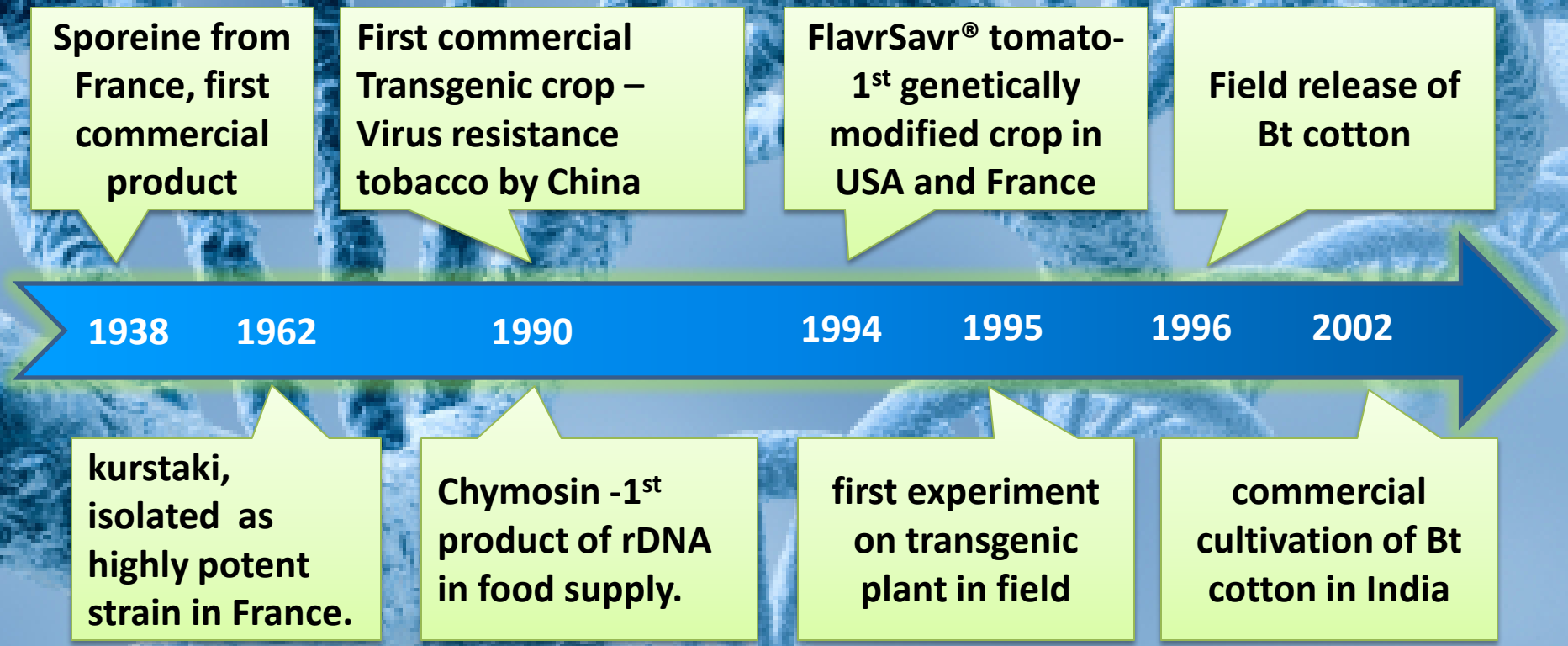
Molecular markers

Molecular diagnostics

Vaccines

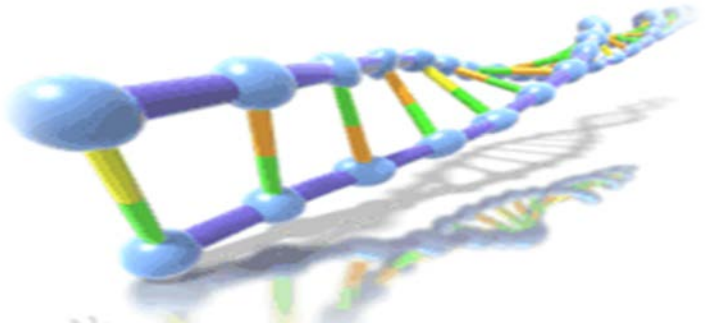
Tissue culture

Timeline of Biotechnology in Agriculture

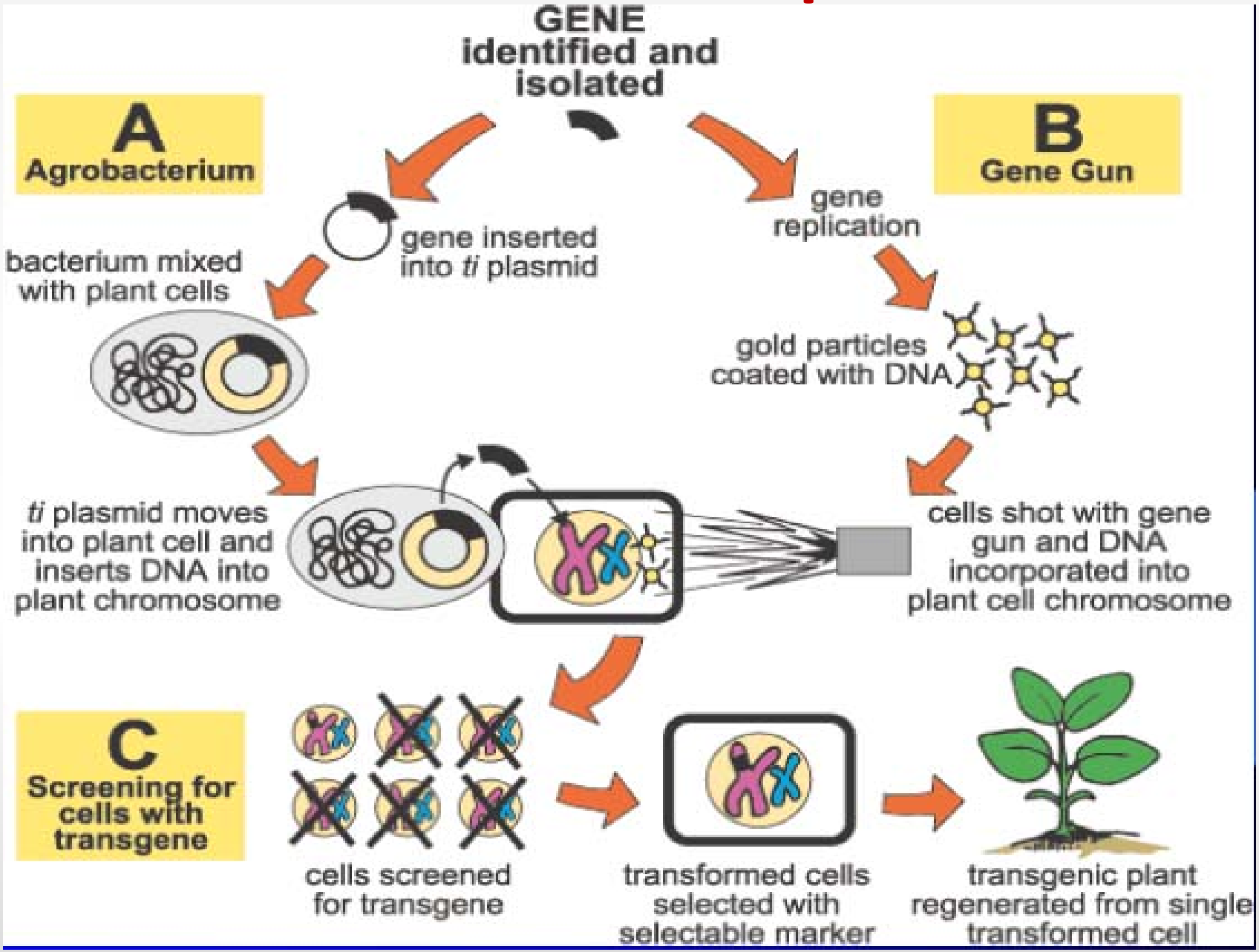


Application of Biotechnology in Agriculture

1. Crop improvement: Improved oil quality in Soybean and Canola
2. Herbicide resistance: Cotton, Corn, Soybean and Rice
3. Insect Resistance: Cotton, Corn, Rice, Tomato and Potato
4. Virus resistance: Papaya, Squash and Potato
5. Slow-ripening and softening: tomato and melon
6. Male sterility: Canola and Corn.



Gene transfer in plants



Development of transgenic crops expressing insecticidal genes

- **Cry toxins *Bt*:** Cry 1 Ab, Cry 1 Ac, Cry IIa, Cry 9c, Cry IIB, Vip I, Vip II etc.
- **Plant metabolites :** Flavonoids, alkaloids, terpenoids
- **Enzyme inhibitors :** SBTI, CpTi
- **Enzymes :** Chitinase, Lipoxigenase
- **Plant Lectins :** GNA, ACAL, WAA
- **Toxins from predators :** Scorpion, spiders
- **Insect harmones :** Neuropeptides and peptide hormones

Insecticidal genes from sources other than *Bacillus thuringiensis*

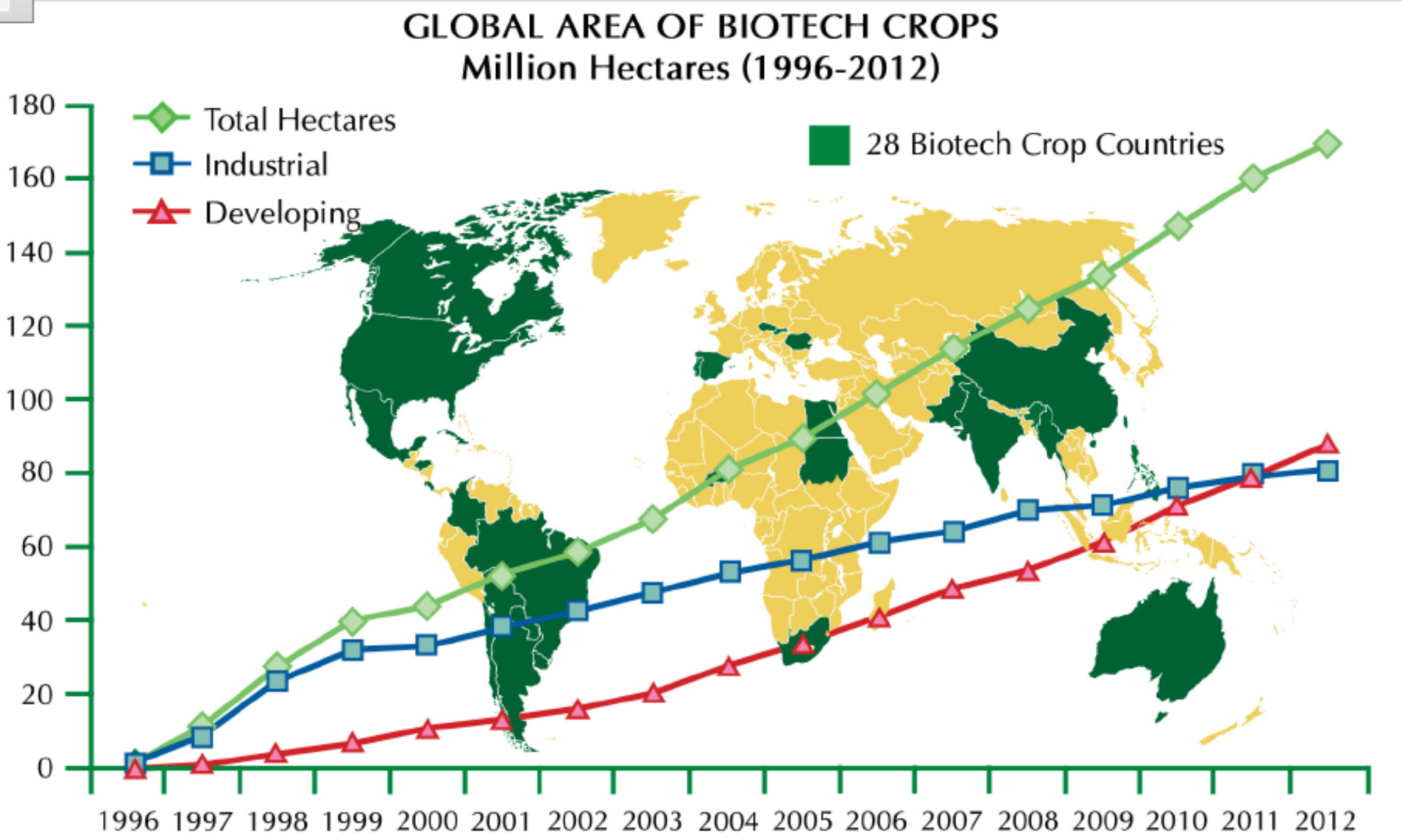
Pyramiding genes: Engineering transgenic crops with more than one gene to get multimechanistic resistance.

Bt cotton

- 1961- Bt was registered as pesticide to the EPA
- 2002: Bt cotton was introduced in India
- India has the largest hectarage of cotton and one third of the total cotton are planted in the world
- Cotton yield increased from 308 Kg/ha in 2001-02 to 500 kg/in 2011-12.

Major transgenic crops expressing Bt genes for Insect Resistance

Transgenic Crop Plants	Foreign Gene	Target insect pests
Cotton	Cry1A(b), Cry1A(c)	*H. armigera, H. zea, Heliothis virescens, Pectinophora gossypiella. S. exigua*
Maize	Cry1A(b), Cry1A(c), Cry9C	*Chilo partellus, H. zea*
Tomato	Cry1A(c)	*Manduca sexta*
Tomato	Bt(k)	*M. sexta, H. zea*
Rice	Cry1A(b), Cry1A(c), CryII(a)	*Scirpophaga incertulas, Cnaphalocrosis medinalis*
Potato	Cry 1A(b), Cry1A(b)6, CryIII A, CryIII B	*Phthorimaea operculella, Leptinotarsa sp.*
Tobacco	Cry1A(c)	*H. virescens, M. sexta,*
Brinjal	CryI AC	*Leucinodes orbonalis*

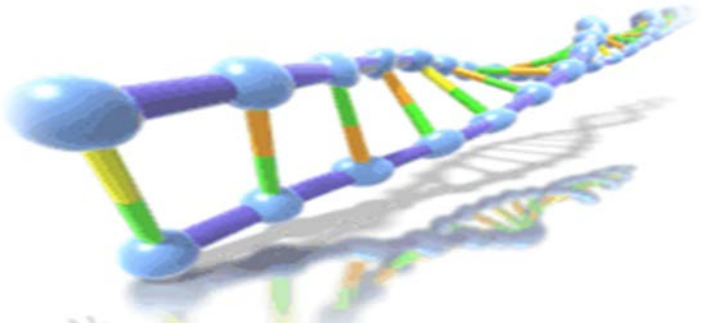


A record 17.3 million farmers, in 28 countries, planted 170.3 million hectares (420 million acres) in 2012, a sustained increase of 6% or 10.3 million hectares (25 million acres) over 2011.

James (2012)

Requirements identified while producing transgenic plants

- Resistance should be controlled by single gene.
- Expression of transferred gene should occur in the desired tissue at the appropriate time.
- Safe for consumption
- Inheritance of the gene in the successive generations should be very stable.



Plant derived genes

Protease inhibitors

- **Antimetabolic proteins which interferes with the process of digestion in insects- strategy by plants.**
- **Dietary protease inhibitors – detrimental to the growth and development of insects**
- **Ex: *Helicoverpa*, *Spodoptera***

α – Amylase inhibitors

- **Inhibit the digest enzymes of mammals and insects.**
- **Seeds of several varieties of common bean, *Phaseolus vulgaris* (BAAI) – exhibit resistance to bruchid beetles, *Callasobruchus* spp.**
- **Transgenic tobacco plants expressing amylase inhibitors from from wheat (wheat α-amylase inhibitor, WAAI) increase the mortality of lepidopteran larvae by 30-40 per cent.**

Lectins

- Plant derived proteins that bind to oligo and polysaccharides
- Causes agglutination and cell agrgregation.
- Carbohydrate binding lectin protein (including chitin) called phytohemagglutinin (PHA) found in seeds of common bean.
- It binds the chitin in peritrophic membrane of midgut thus interfere with nutrient uptake.

  Wheat (wheat germ agglutinin, WGA) and snowdrop (*Galanthus nivalis* agglutinin, GNA) } Inhibitory to homopteran pests- aphids, plant hoppers and leaf hoppers

- Alternative to Bt delta endotoxins.

Biotechnological methods employed for crop improvement

Sl. No.	Technique	Application	Examples
1	*Agrobacterium-based* plant transformation	Ti- plasmid –to carry novel DNA into plants	Bt insect resistant crop plants
2	Particle acceleration	DNA coated gold particles fired into growing tissue	Transgenic soybean
3	Electroporation	Electric current used to alter protoplast membranes permitting DNA uptake	Transgenic rice
4	Microinjection	DNA injected into the nucleus or cytoplasm of a protoplast	Transgenic tomato
5	RNA interference	Blockage of gene function by inserting short sequences of RNA	Potential for protecting cotton, rice and maize against insect pests

Atwal and Dhaliwal, 2013

Genetic engineering of Predator and Parasitoids

- Transgenic strain of *Metaseilus occidentalis* Predator of spider mite
- Maternal microinjection
- Transgenic strain can be used routinely in applied pest management programme

(Hoy, 2000)

Genetic improvement of predators & Parasitoids

- **Resistance to pathogens**
- **Resistance to pesticides**
- **Adaptation to different environmental conditions**
- **High fecundity**
- **Improved host seeking ability**

Potentials of biotechnology in IPM

- Low toxicity of protease inhibitors and Bt δ- endotoxin as compared to conventional insecticide.
- Expression of toxins in all plant parts - No need of continuous monitoring of pest.
- Provide protection to those plant parts which are difficult to be treated with insecticides.
- There is no drift problem and ground water contamination.
- Safe to non target species and human beings.
- Eliminate the problem of shelf life and field stability faced by pesticide formulation.
- Inbuilt resistance to various insects.

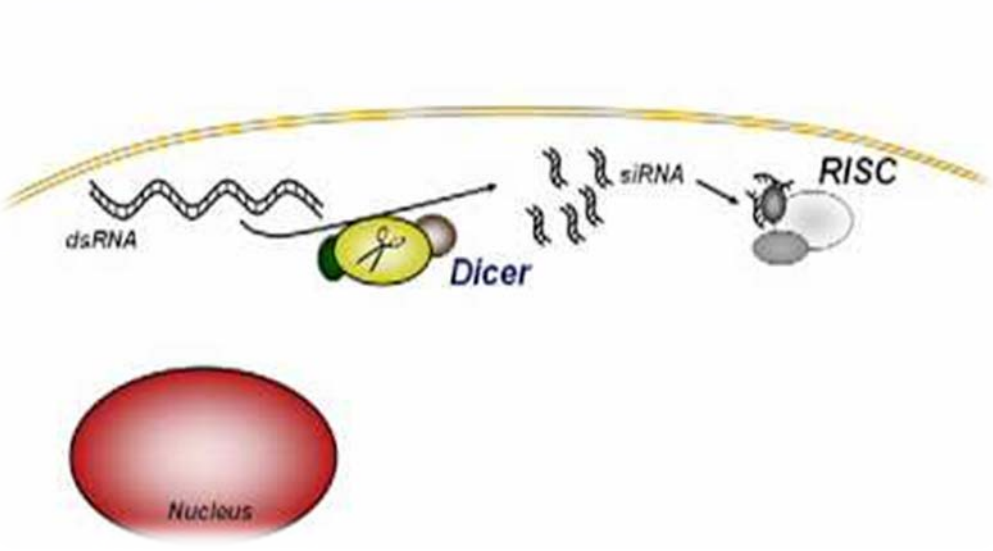
Risk associated with Biotechnological approaches

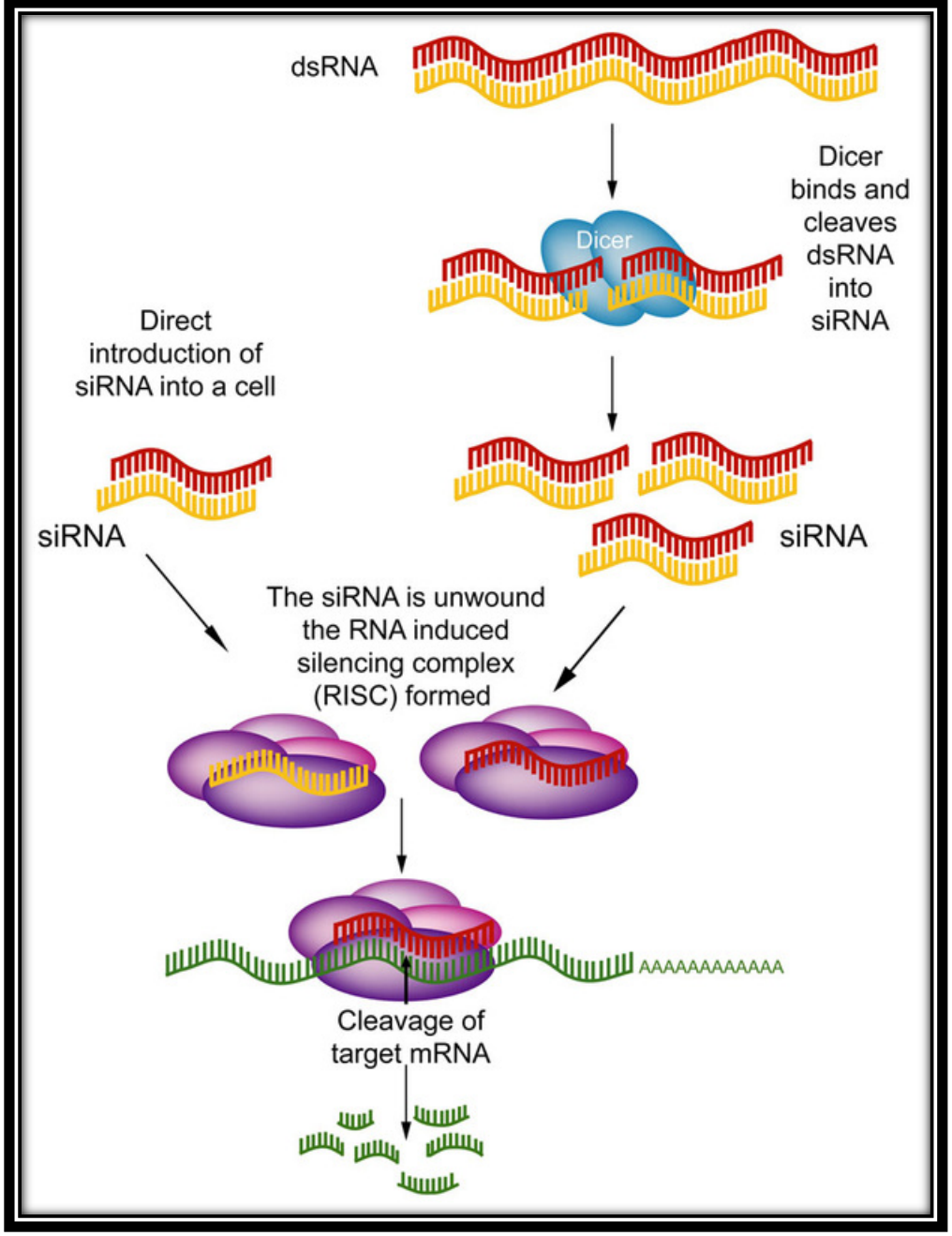
- **Human and animal health: Toxicity, food quality, allergenicity**
- **Risk for agriculture: loss of biodiversity, alternation in nutritional level, development of resistance.**
- **Risk for environment: persistence of gene, unpredictable gene expression, impact on non target organisms.**
- **Risk for horizontal transfer: interaction among different genetically modified organisms, genetic pollution through pollen or seed dispersal, transfer of gene to microorganism.**

RNA interference

- Method of blocking gene function by inserting short sequences of double stranded ribonucleic acid (dsRNA) that match part of the target mRNA sequence, thus no proteins are produced.

- Knock down the expression of genes.





Mechanism of RNA interference (RNAi) in cell

Jindal *et al.*, 2012

Major Indian centres in transgenic research & application

- Seven such centres were set up initially at various Universities/Institutions namely,
- Jawaharlal Nehru University (New Delhi),
- Madurai Kamaraj University (Madurai),
- Tamil Nadu Agricultural University (Coimbatore),
- Osmania University (Hyderabad),
- National Botanical Research Institute (Lucknow) and
- Bose Institute (Kolkata).
- University of Delhi South Campus in 1997.

Conclusion

- Biotechnological approaches play important role in insect-pest management.
- The efficacy of bio-control agents can be increased through rDNA technology
- DNA barcoding can help in quick and accurate identification.
- DNA fingerprinting helps for identification of biotypes and genetic changes in insect-pest.