Previous Class

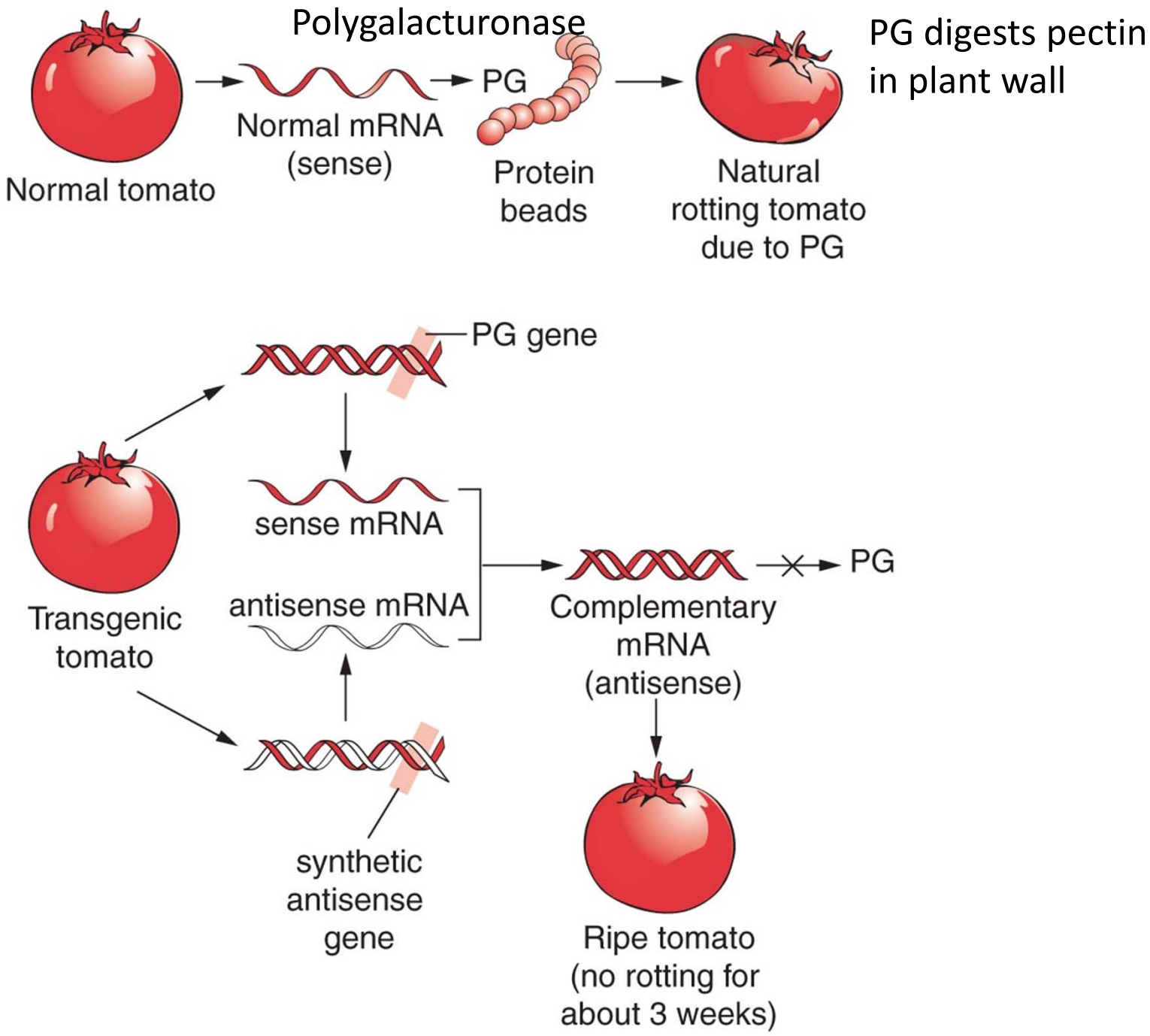
- Plant transgenesis
- Classic breeding
- Polypoid plants
- Cloning
- Protoplast fusion
- Leaf fragment technique
- Gene Guns

Chloroplast engineering

- DNA in chloroplast can accept several new genes at once
- High percentage of genes will remain active
- DNA in chloroplast is completely separate from DNA released in pollen – no chance that transformed genes will be carried on wind to distant crops

Antisense technology

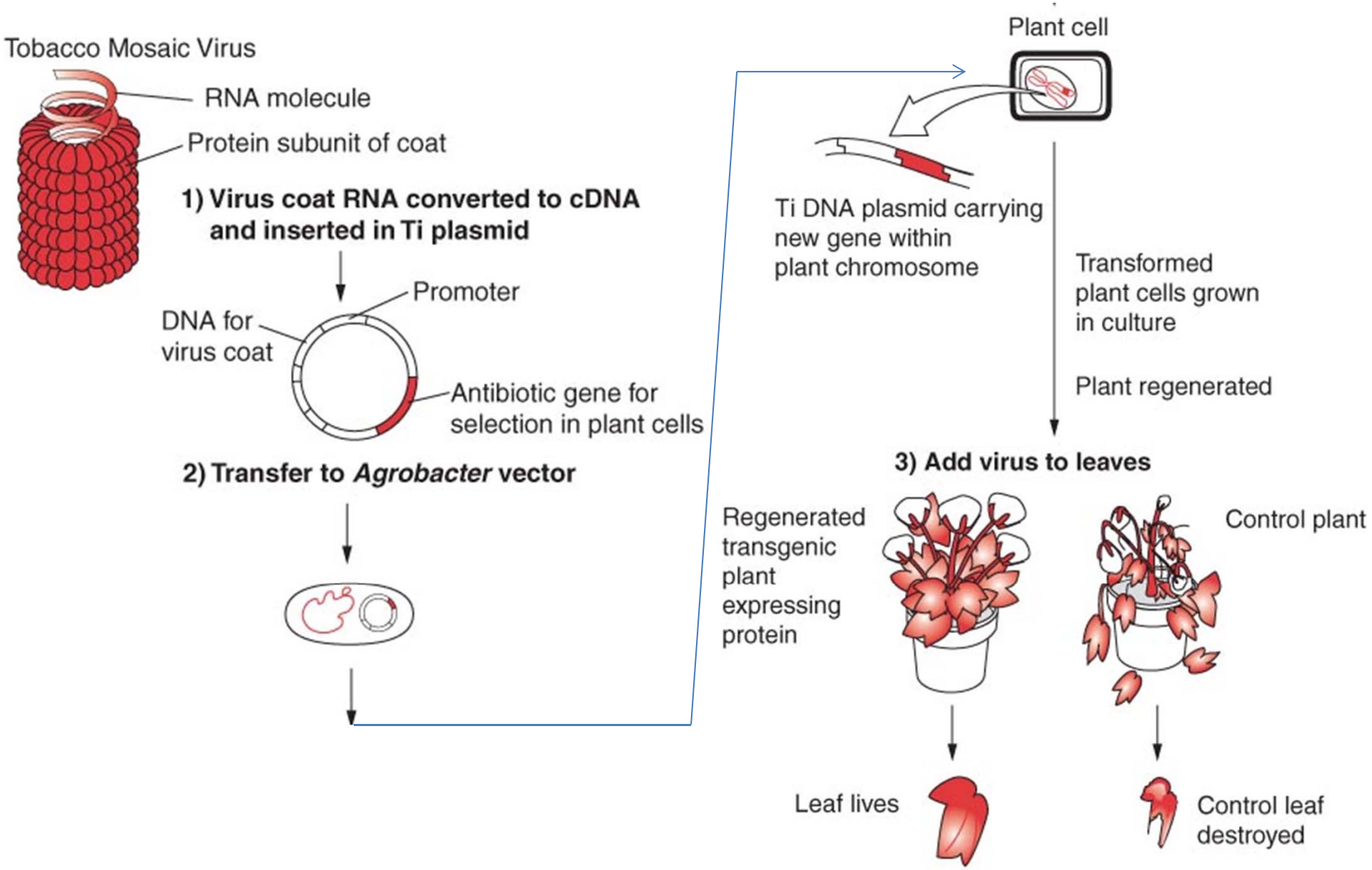
- Process of inserting a complementary copy of a gene into a cell
- Gene encodes an mRNA molecule called an antisense molecule
- Antisense molecule binds to normal mRNA (sense molecule) and inactivates it
- Example is *Flavr Savr* tomato
  - Fruit of this tomato and of similarly modified crops are ripened “on command” by treating on the vine with ethylene, giving freshness, improved flavor and reduced spoilage.


Polygalacturonase
PG digests pectin in plant wall
Normal tomato
Normal mRNA (sense)
PG
Protein beads
Natural rotting tomato due to PG
PG gene
sense mRNA
antisense mRNA
Transgenic tomato
Complementary mRNA (antisense)
PG
synthetic antisense gene
Ripe tomato (no rotting for about 3 weeks)

Practical Applications in the Field

- Vaccines for Plants
  - Crops are vulnerable to a wide range of viruses
  - Vaccine is encoded in a plant's DNA
  - For example, a gene from Tobacco Mosaic Virus (TMV) inserted into tobacco plants
    - Protein produced from the viral gene stimulates the plant's immune system
    - Plant is invulnerable to virus

Plant Vaccines



Genetic Pesticides

- *Bacillus thuringiensis* (Bt) is a bacterium that produces a protein that kills harmful insects and their larvae – *Cry* gene
- On consumption of this crystalline protein insects die from autodigestion
- Bt genes (producing Bt toxin) can be inserted into a plant's DNA
  - Creates a built-in defense against certain insects
- Controversy surrounding Monarch butterflies – pollens produced by bioengineered plant could be deadly to Monarch butterflies

Safe Storage

- Millions of dollars are lost every year to insect infestations of crops during storage
- Transgenic corn that expresses **avidin** is highly resistant to pests during storage
  - Avidin blocks the availability of biotin, a vitamin required by insects to grow

Herbicide Resistance

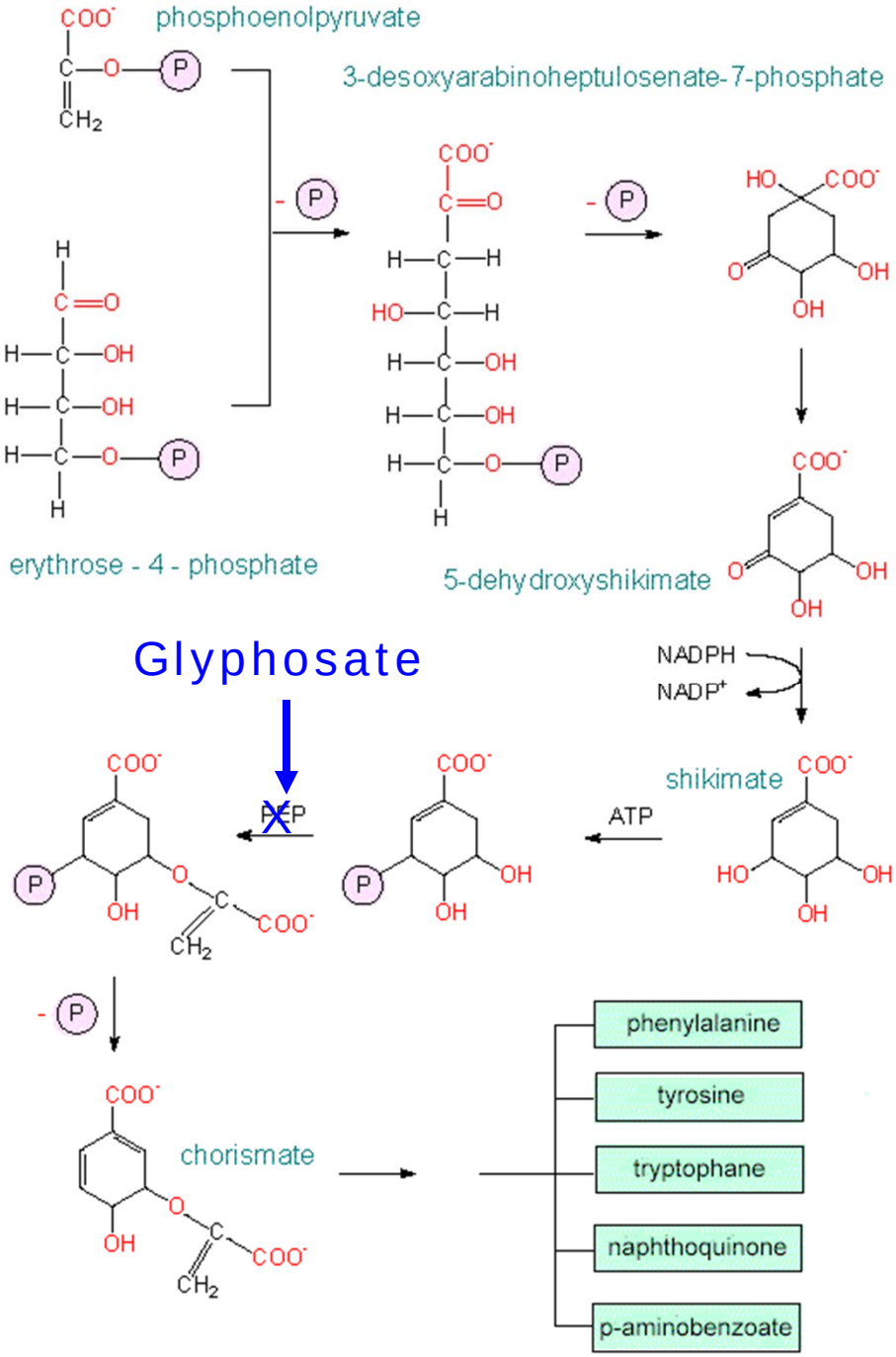
- Traditional weed killers kill desirable plants also
- Genetically engineer crops to be resistant to common herbicides
- Allows farmers to control weeds with chemicals that are milder and more environmentally friendly than typical herbicides

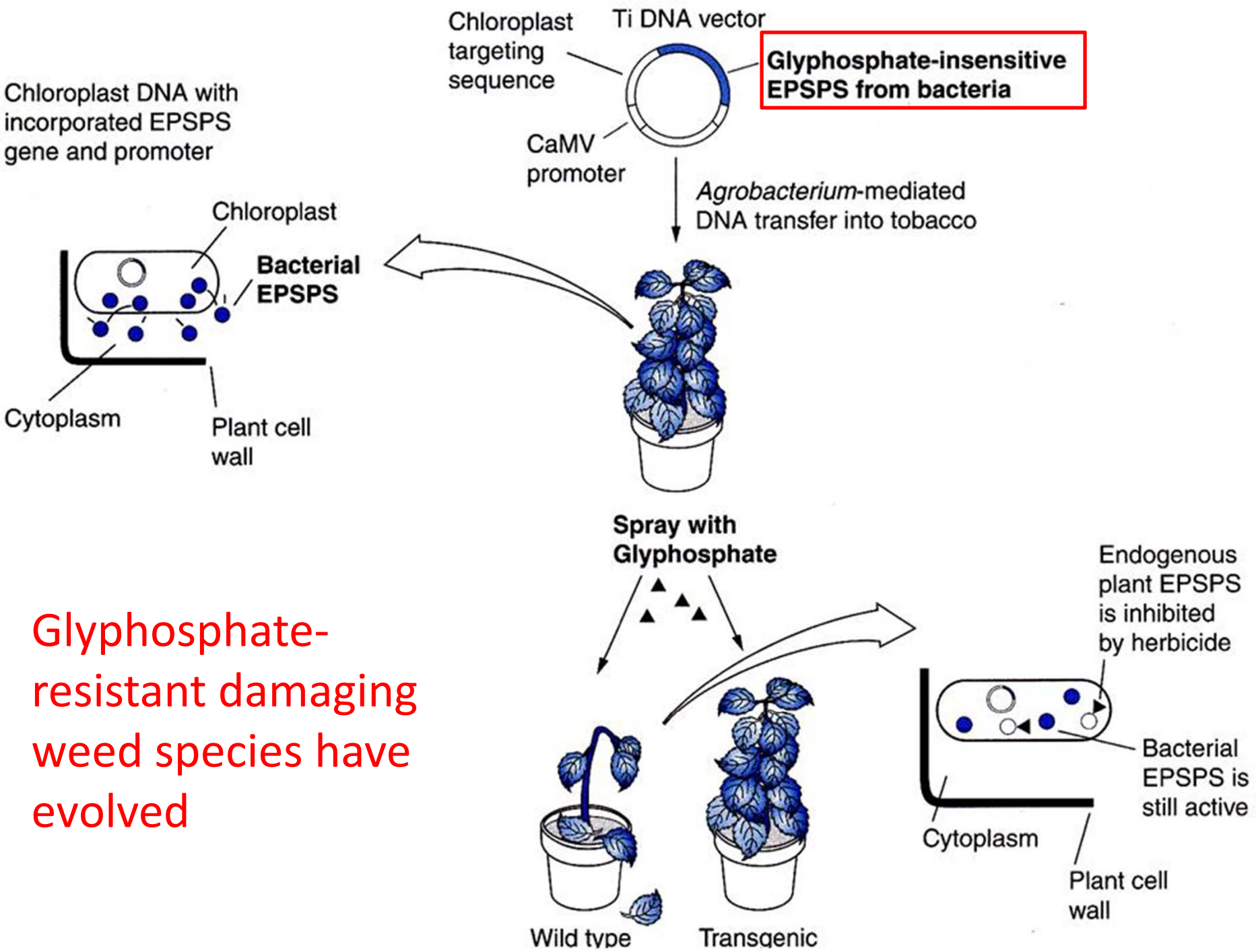
Examples of crop improvement through genetic engineering

- Engineered herbicide resistance
  - Glyphosate (RoundUp™) and EPSP synthase

Shikimate pathway

EPSP (3-Phospho-5-enoylpyruvylshikimate)





Glyphosphate-resistant damaging weed species have evolved

Lab Testing The Transgenics

Insect Resistance

Transgene=

Bt-toxin protein

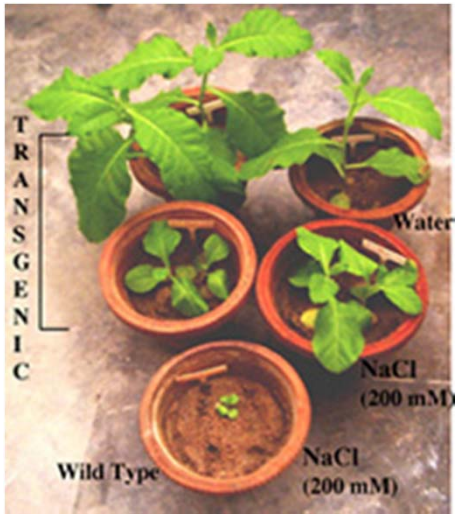
Cold Tolerance

Transgene=

CBF transcription factors

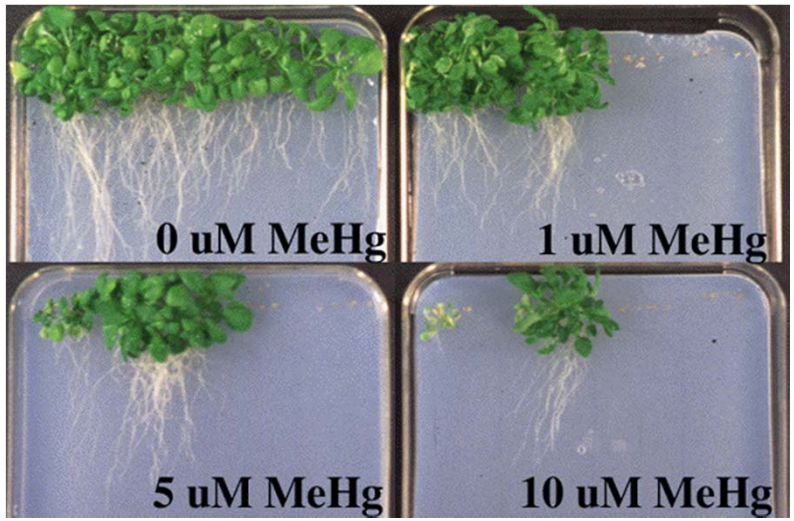
More Modern Examples

Salt Tolerant



Transgene=
Glyoxylase I

Mercury Resistance



Transgene=
Mercuric ion reductase

The Next Test Is The Field

Herbicide Resistance

Non-transgenics

Transgenics

Final Test

Consumer Acceptance

RoundUp Ready Corn

Before

After

The Public Controversy

- Should we develop transgenics?
- Should we release transgenics?
- Are transgenics safe?
- Are transgenics a threat to non-transgenic production systems?
- Are transgenics a threat to natural eco-systems?

- Enhanced Nutrition
  - Golden rice has been engineered to contain large amounts of beta carotene, which the body converts to vitamin A

6.3 Practical Applications in the Field

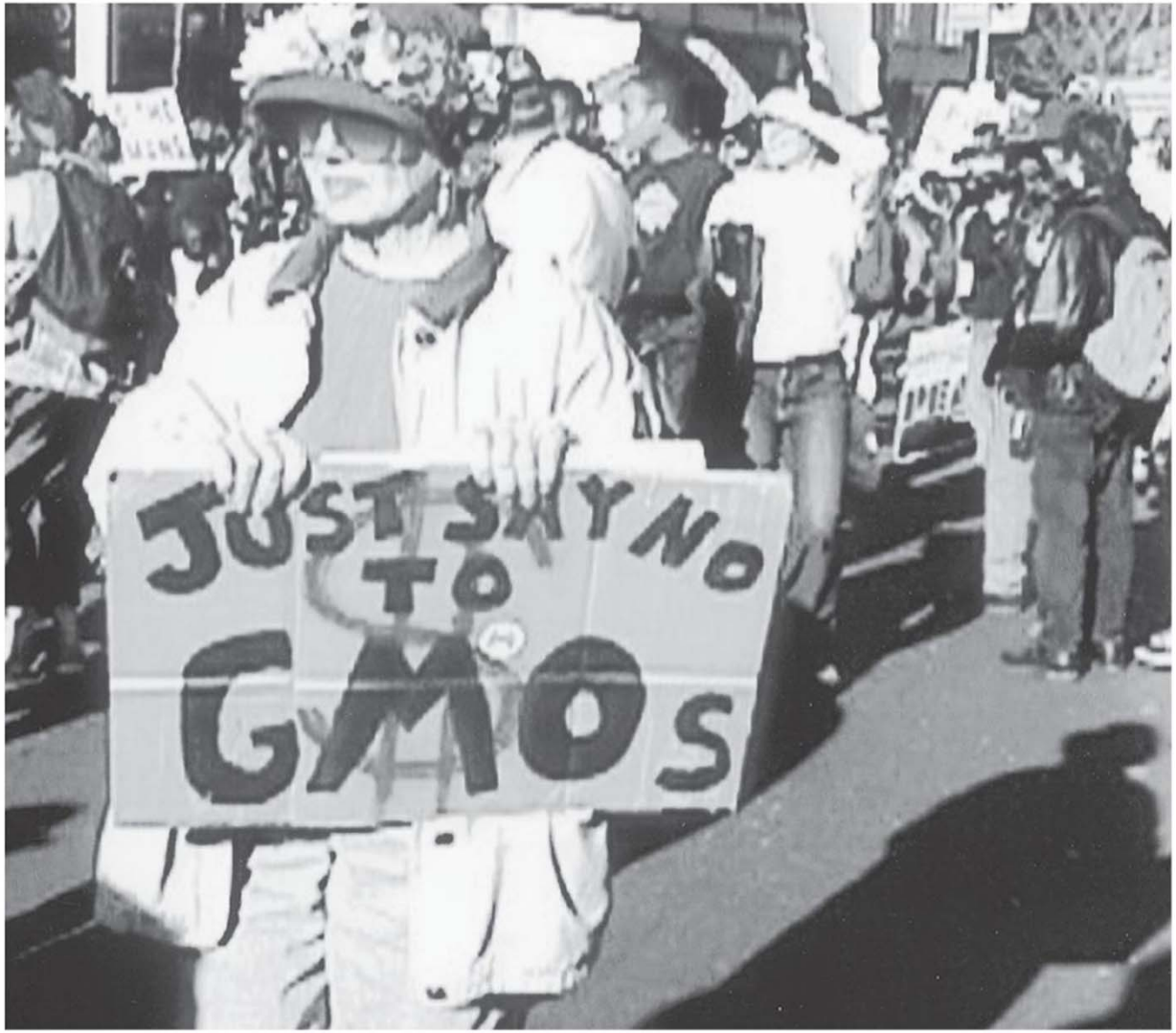
Practical Applications in the Field

- The Future: From Pharmaceuticals to Fuel
  - Plants can be ideal protein factories
  - Used to grow medicines
    - Vaccines for humans, antibodies, human insulin
  - Plant-based petroleum for fuel, alternatives to rubber, nicotine-free tobacco, caffeine-free coffee, biodegradable plastics, stress-tolerant plants

Practical Applications in the Field

- Metabolic Engineering
  - Manipulation of plant biochemistry to produce non-protein products or to alter cellular properties
    - Alkaloids, lipids, polyterpenes, pigment production, and biodegradable plastics
  - Involves transfer of more than one gene and more finite regulation

Health and Environmental Concerns



Health and Environmental Concerns

- Human Health
  - Opponents fear the effects of foreign genes, bits of DNA not naturally found in plants
    - Allergic reactions
    - Antibiotic-resistance marker genes could spread to disease-causing bacteria in humans
    - Cause cancer
  - To date, science has not supported any of these concerns

Health and Environmental Concerns

- Environmental Concerns
  - Genes for pest or herbicide resistance could spread to weeds
  - Few experts predict this will happen; further studies are needed
- Regulation
  - FDA regulates foods on the market
  - USDA oversees growing practices
  - EPA controls use of Bt proteins and other pesticides

Concerns about genetically modified foods

- Human health
  - Unsuspected allergens
  - What other issues are there?
- Environment
- Messing up the gene pool of non-target species in the environment
  - Lateral gene transfer
    - Still poorly understood in nature

Summary

- Variety of techniques are available to introduce genes into plants and have the plants express the gene
- Such genetic engineering is used to
  - Improve disease resistance
  - Flavor of product
  - Nutrition of product
  - Shelf life of product
  - Any other property of plant that improves its value