

A growing concern: Vulnerability of the food supply to contamination by pharmaceutical and industrial crops

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Outline

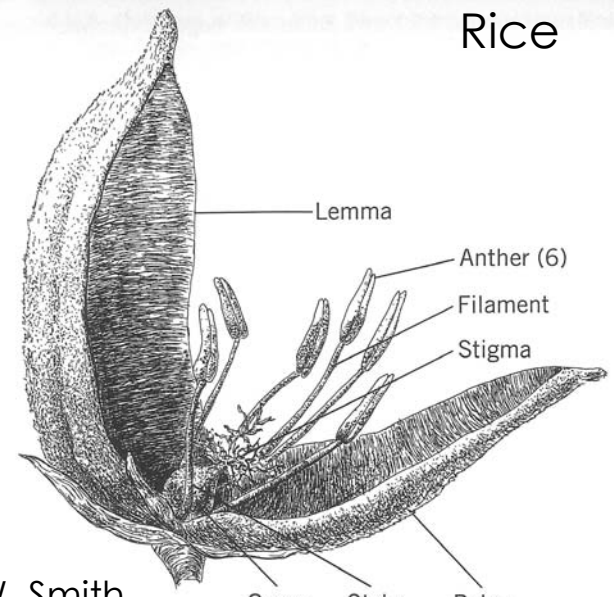
- Pharmaceutical and industrial crops
- The agricultural production cycle
- Escape routes of genes in this cycle
- The concept of “virtually zero” contamination

“Pharma” and Industrial Crops

- Crops that have been genetically engineered to produce a pharmaceutical or industrial compound
 - Pharmaceutical: *e.g.*, drugs, hormones, vaccines
 - Industrial: *e.g.*, plastics
- Why plants?
 - Reduce production costs compared with cell culture or fermentation systems

Main Crops Pursued

- Maize, soybean, rice, tobacco
 - Major crops:
 - Maize, soybean: ~ 70-80 million acres each
 - Rice: 2-3 million acres
 - Tobacco: 300,000 acres
 - Better-known biologically and agronomically
 - Most are crops for human consumption:
 - Direct or processed
 - Different reproductive biology:
 - Cross-pollinated: Maize
 - Predominantly self-pollinated: Soybean, rice, tobacco



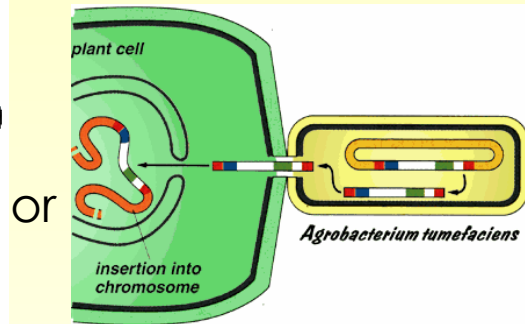
C.W. Smith

Photos: P. Gepts

Agricultural production cycle: *In planta* production

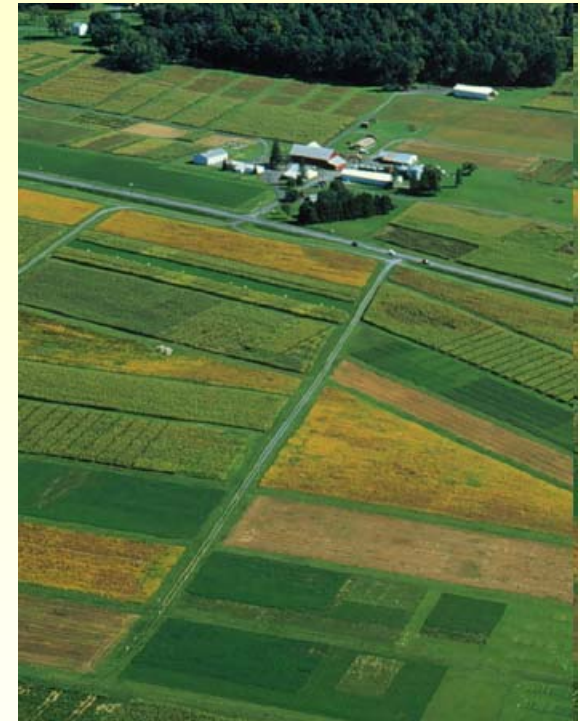
- Development of transgenic varieties
 - Genetic engineering
 - Plant breeding
 - Seed certification
- **The cycle itself**
 - Field preparation
 - Planting
 - Cultivation practices
 - Harvest
 - Post-harvest
- Off-farm “shipping and handling”
 - Transportation and storage
 - Processing

Development of Transgenic Varieties



or

Genetic engineering
Field testing
Plant breeding
Seed certification



Close Physical Arrangement

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What happens in one field has likely an impact in the adjacent fields

Agricultural Production Cycle



Transportation and Processing



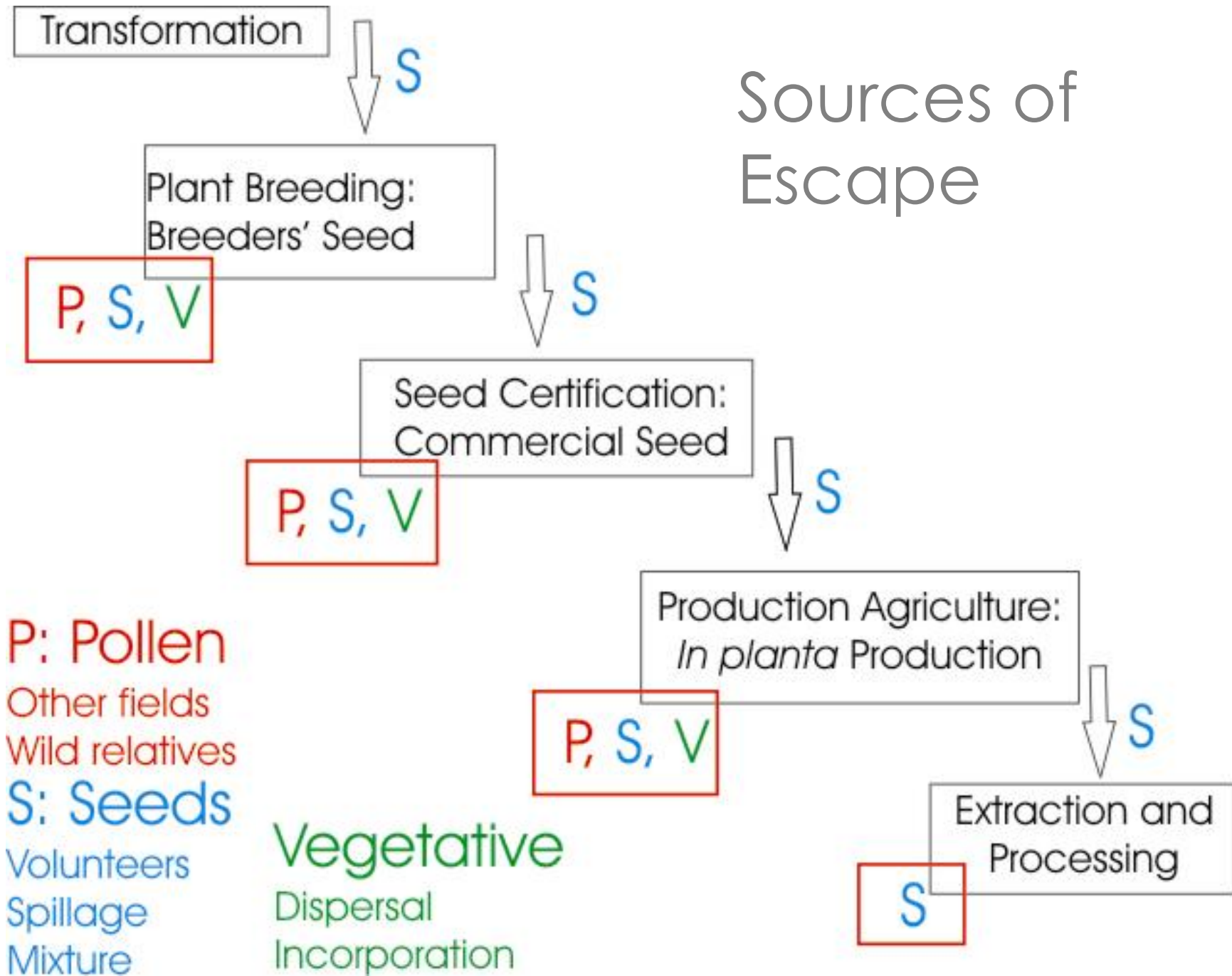
Contamination

- Definition:
 - The presence of pharma transgenes or their products where they are not wanted.
- Sources of contamination:
 - Pollen
 - Seed

Pollen and Seed Movement

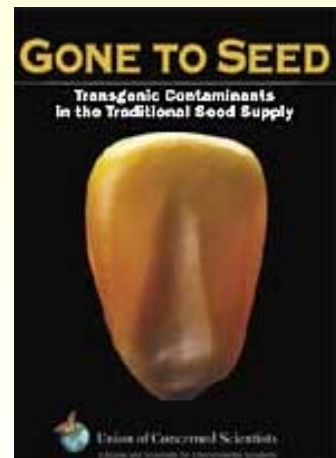
- Pollen
- Seed
 - Dispersed either naturally or by wind or animals
 - By human handling
 - Spillage during seed production, harvest, transportation, and storage
 - Mixed with other seed stocks during these same operations.
 - For example:
 - Spilled during harvesting → “volunteers” in the next growing season.
 - Grain residues left in a harvester can lead to the mixing of grain from different sources of the same crop.

Sources of Escape



Cases of Inadvertent Gene Flow

- UC Davis: transgenic tomato genetic stock
- UCS:
 - Gone to Seed
- Liberty Link rice



Concept of Virtually Zero Contamination

- The likelihood of contamination is so low that contamination is nearly zero:
 - Zero contamination is impossible to achieve
- Pro-active approach:
 - Pharma production
 - Take measures to prevent gene flow *ab initio*
 - Avoid retrofitting the production system

Preventing Contamination through Seed and Pollen

- **Zoning**: outside production areas
- **Spatial separation**: in production areas, beyond cross-pollination distance
- **Temporal separation**: avoid overlapping flowering
- **Dedicated infrastructure**: machinery, equipment
- **Physical confinement**: indoors
- **Biological confinement**: reducing pollen and seed dispersal
- **Disallowing food/feed crops**

Alternative Pharma Crops

- No role as food or feed crops
- Amenable to restriction of pollen and seed dispersal
- Organ or tissue for pharma production:
 - easily stored and amenable to drug purification
- Production infrastructure available
- Molecular information to produce pharma compounds in the desired tissue

Evaluating confinement measures

- Effectiveness in eliminating pollen and seed dispersal
- Cost
- Readiness for use
- Enforceability
- Scalability

No single measure is effective to achieve **Virtual Zero Contamination**. No system in existence right now.

Preliminary Examples of Potential Alternative Pharma Crops

- Tobacco:
 - Most prospect for an alternative

- Guayule:
 - 5-10 years needed after decision to commit

- Jojoba:
 - More than 10 years



Summary

- Agricultural production
 - Potential advantages: cost
 - Contamination concern
 - Seed and pollen movement:
 - Pharma compounds and transgenes
- Various confinement methods
 - None is sufficient on its own
 - The combination is not in existence