

GM Food Ethics

PHIL/BIOL 2510, Spring 2009
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Review

- Methods
 - Agrobacterium
 - Gene Gun
- Uses (plants)
 - Herbicide Resistance (Ht)
 - Insect Resistance (Bt)
 - Others

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To start with...

Do you have any reservations about eating GM food?

Why is there a push for GM agriculture?
Profit or Humanitarian reasons?

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Outline

- Context:
 - The Green Revolution
 - Big Agri-business
- Safety Issues:
 - Human Health
 - Environmental Issues
- Socio-Economic Issues
 - Global Perspectives
 - Case Study: Golden Rice

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Green Revolution

- Industrialized use of agricultural technology
 - Irrigation, fertilizers, pesticides, herbicides, and seed development (hybrids)
- Started in 1945 Mexico wheat, then expanded to other regions, India, SE Asia, S. America... Dramatic increases in yield.
- Addressed food shortage and increased human population & has dramatic social and economic impact.
- Involved Biotech and Policy in ways that produced large and global Agri-business.

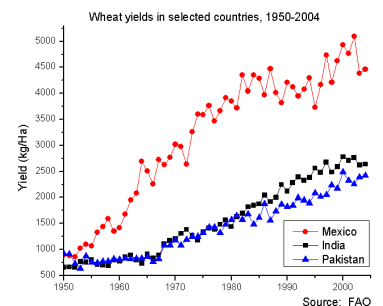


Norman Borlaug
1970 Nobel Peace Prize

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Green Revolution

- Rapid increase in crop yield
- Move country/region from consumer to producer of grains
- Economic & social benefits
- What risks?



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GM Agriculture

- Apply rDNA technology to agriculture (circa 1995)
 - Insert useful genes into major crops
 - Ht, Bt, drought, disease, salinity, nutrition, energy, etc.
 - Impetus for Biotech Agri-businesses
- Rapid Expansion of Green Revolution
 - Reduce use of pesticides and herbicides
 - Further increase yield and crop viability
 - Address hunger, malnutrition, poverty...

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Global Crops



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GM Food: Benefits

- Producers & Consumers
 - Pest resistance
 - Herbicide tolerance
 - Disease resistance
 - Cold and Drought/Salinity tolerance
 - Added Nutrition & Pharmaceuticals
- Environment
 - Reduce use of pesticides and herbicides = fewer chemicals
 - Increase yield, thus more efficient use of land
 - More precise control of crop modification
- Socio-Economic
 - Address food shortages and adapt previously unusable land
 - Increase national yield, reduce dependence
 - Deliver nutrition or drug therapy cheaply and efficiently

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Safety: Human Health

- **Toxins**
 - Ht and Bt explicitly produce toxins or resistance to toxins that will be consumed by humans. Possibly exposing humans to greater toxicity than in non-GM crops.
- **Allergic Reactions**
 - Introducing transgenes from organisms that may produce proteins (known and unknown) that humans are allergic to might be hazardous. E.g. Brazil nut example.
- **Long-Term Effects?**
 - The principle of unintended consequences tells us to be on the look out for unanticipated risks/harms. With GM foods the long-term effects on human health are unknown, but currently no reliable indicators that there has been harm.

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Responses to Health Concerns

- Avoid introducing genes from toxic or allergenic plants
 - a proposal to introduce a gene from Brazil nuts into soybeans was abandoned because of possible allergic reactions.
 - Continued vigilance and reliable testing, but currently no known reactions
- Novel allergies or toxins should be tested for or tracked in use.
 - How do we do this?
- Long-term effects are unknown
 - No known adverse effects since GM Food introduced (Billions served)
 - Principle of Substantial Equivalence (below)

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Substantial Equivalence

"Food is considered safe if there is reasonable certainty that no harm will result from its consumption under anticipated conditions. Historically, food prepared and used in traditional as is considered safe on the basis of long-term experience, even though it may naturally contain harmful substances. In principle, food is presumed to be safe unless a significant hazard has been identified." (OECD Report, 1993)

IN OTHER WORDS: Compare the GM Crop with a relevantly similar crop to indicate what is different in terms of risk. If there is no significant difference, they are substantially equivalent, and no further risk assessment is needed. If there is a difference they are not substantially equivalent, and thus need further risk assessment.

- Compare risk assessment between toxicological studies with studies of whole foods.
- Might be too risky, exposing people to undue risk.

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Environmental Impact

- **Selection Pressure**
 - Use of Ht and Bt crops exerts profound selection pressures on weeds and insects, perhaps producing "super-weeds" or "super-bugs" that will adapt to Ht and Bt varieties.
- **Gene Flow**
 - Crops may cross with wild plants or other organisms thus introducing the transgene into the wild. Possible consequences include "invasive species" effects, increased selection pressures, or environmental degradation.
- **Crop Biodiversity**
 - The success of GM Crops may increase use of these crops thus reducing the biodiversity of crops to "monoculture." Lower biodiversity risks whole scale collapse of crops if successful disease or pest invades; e.g., Irish potato famine. (Also, threats to non-target species.)

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Responses to Environmental Impact

- **Selection Pressures**
 - Avoid creating resistant bugs/weeds by creating "refuge areas" that reduce selection pressures. (see next slides)
 - Even if super-bugs/weeds develop, employ new Ht or Bt varieties.
- **Gene-flow**
 - create sterile plants or remove gene from pollen. (Terminator technology?)
 - Limited chance: only observed in closely related species
- **Crop Biodiversity**
 - Caution in depending on single varieties (monoculture)
 - Develop responses to potential collapse

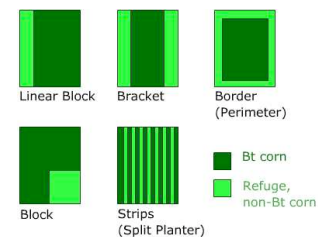
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Refuge Areas

In the US, the EPA requires Bt corn farmers implement refuge areas to these guidelines:

• Growers may plant up to 80% of their corn acres with Bt corn. **At least 20% must be planted with non-Bt corn (refuge area)**

• Refuge area must be within, adjacent to or near the Bt cornfields. it must be placed within 1/2 mile of the Bt field.

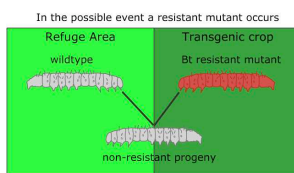


http://www.bt.ucsd.edu/crop_refuge.html

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Refuge area

Resistant mutants will have to breed with non-resistant mutants from the refuge area. (Resistance is recessive.)
Reduce chance of mating with other resistant mutants.



Precautionary Principle

Principle #15 of the 1992 Rio Declaration:

"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

IN OTHER WORDS: Be careful before implementing technology, especially for technology that may difficult to remove or reverse once a problem is discovered.

- Politically intended to counteract policies and regulations that are not precautionary, such as risk-benefit calculations that favor the introduction of new technologies (substantial equivalence?). Thus placing burden of proof on those who wish to introduce the technology, not on the public that might be at risk.
- Might be too (vague and) restrictive, limiting the development and implementation of valuable technology.

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Which principle should guide decisions about GM crops?

- | | |
|--|--|
| Precautionary Principle | Substantial Equivalence |
| • Safety first... | • See as we go... |
| • But may hold up implementing crucial technology (e.g., feed the hungry). | • But may put people at undue risk, and for harms that would be difficult to remove once discovered. |

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A Safety or Economic Issue?



Refuge areas (20% non-transgenic) are designed to avoid producing a “superbug”.
Why would a farmer NOT plant a refuge area?

Public Response: Safety or Economics?



Global Perspective

- The public remains wary of GM crops, especially in Europe. Appeals to safety issues and economic dependence are chief among the complaints.
- Following a precautionary principle, many countries prohibit the growing, import or sale of GM food products. In countries that allow GM foods, some require the food to be specially labeled. Result: International trade between countries that allow GM crops and countries may be limited.
- Shipments of corn and rice from the U.S. to Europe and Asia have been rejected due to the presence of transgenic products in the shipment. Even food aid shipments to India and countries in Africa have been turned back because of GM concerns.
- Increased pressures on food security (food crisis 2008) may place greater value on GM food crops, as an import, export, and adopted agricultural practice.

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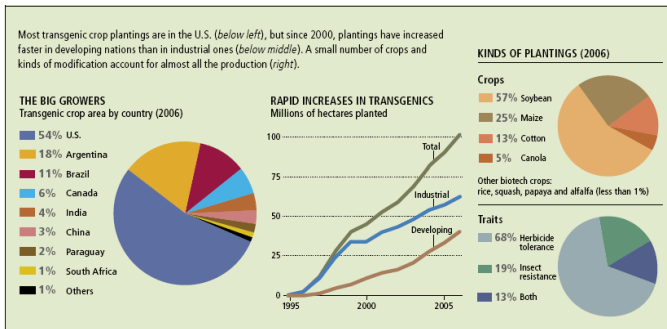
2008 Food Riots

- Increased food prices:
 - Wheat up 77%
 - Rice up 141%, etc.
- Caused by changes in demand, not supply:
 - Increased demand from China and India eating more grain and meat due to increase wealth
 - But prices effect least well off the most: \$1 a day.
- What are the implications?
 - Reduce resistance to GM Foods?
 - Developing human population and food demands

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Nevertheless

T. Raney and P. Pingali. Sowing a gene revolution. *Scientific American*, September 2007; 104-111 pdf available on course website



Socio-Economic Issues

- **Economic Impact**
 - We have already seen the powerful economic impact of the Green Revolution, so it is no surprise that developing countries want to capitalize on it; but infrastructure and indigenous research are limited.
- **Human Health and Biodiversity**
 - Are developed countries dumping GM Foods on a hungry market without proper safety precautions?
 - Reduction of local crop diversity (Monoculture)?
- **Who benefits? Who is at Risk?**
 - Humanitarian efforts need money, but Global Agribusiness consolidates this technology and requires profit to proceed. (e.g., patents and terminator technology?)
 - Are local (developing nations) left out of the agribusiness? Is there a “genetic divide” that perpetuates global inequalities or dependencies?

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Case Study: Golden Rice

- Plants can be modified to contain higher levels of nutrients or nutrients that they don't usually contain.
- Malnutrition is a serious problem in impoverished regions
 - Vitamin A deficiency results from a diet that lacks component nutrients (provitamins; e.g., beta-carotene), such as a diet of mostly rice.
- Golden Rice to the rescue!
 - Includes transgenes from bacteria and dandelion flowers, to increase beta-carotene levels.
 - Marketed as an altruistic effort of biotech companies to remedy this problem.



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Golden Rice: Objections

- Doesn't really address malnutrition problem...
 - Quantity of rice required to have nutritional benefit far exceeds reasonable daily consumption.
 - To benefit from additional nutrition need fat in diet, but not available for poorest.
- Reduce biodiversity of local crops...
 - Imports non-native varieties, replacing native diversity
 - Large scale agriculture tends toward monoculture.
- Economic dependency...
 - Ultimately leads to agricultural dependence on Agri-business who develops technology.

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Golden Rice 2

Paine et al. 2005. Improving the nutritional value of Golden Rice through increased pro-vitamin A content. *Nature Biotechnology* 23(4): 482-487.

Tried different genes from plants that make yellow or orange parts (carrots, tomatoes, corn, peppers etc.) to see if they could make a better golden rice. Turns out Daffodil (the gene they used in the original golden rice) was the worst choice of the bunch. The same gene but from corn makes golden rice that is orange with carotene- apparently 1/4 pond of rice will give you a full daily dose. They call it Golden Rice 2. Still at experimental stage, test crops.

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