Genetically Modified Foods

Global Seminar

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Biofortification of Staple Food Crops:
A Sustainable Solution to Micronutrient Malnutrition?

A Case Study

Dennis Miller

Supporters hail genetic engineering as essential for addressing food insecurity and malnutrition in developing countries.

Opponents counter that it will wreak environmental havoc, increase poverty and hunger, and lead to a corporate takeover of traditional agriculture and the global food supply.

FAO, 2004

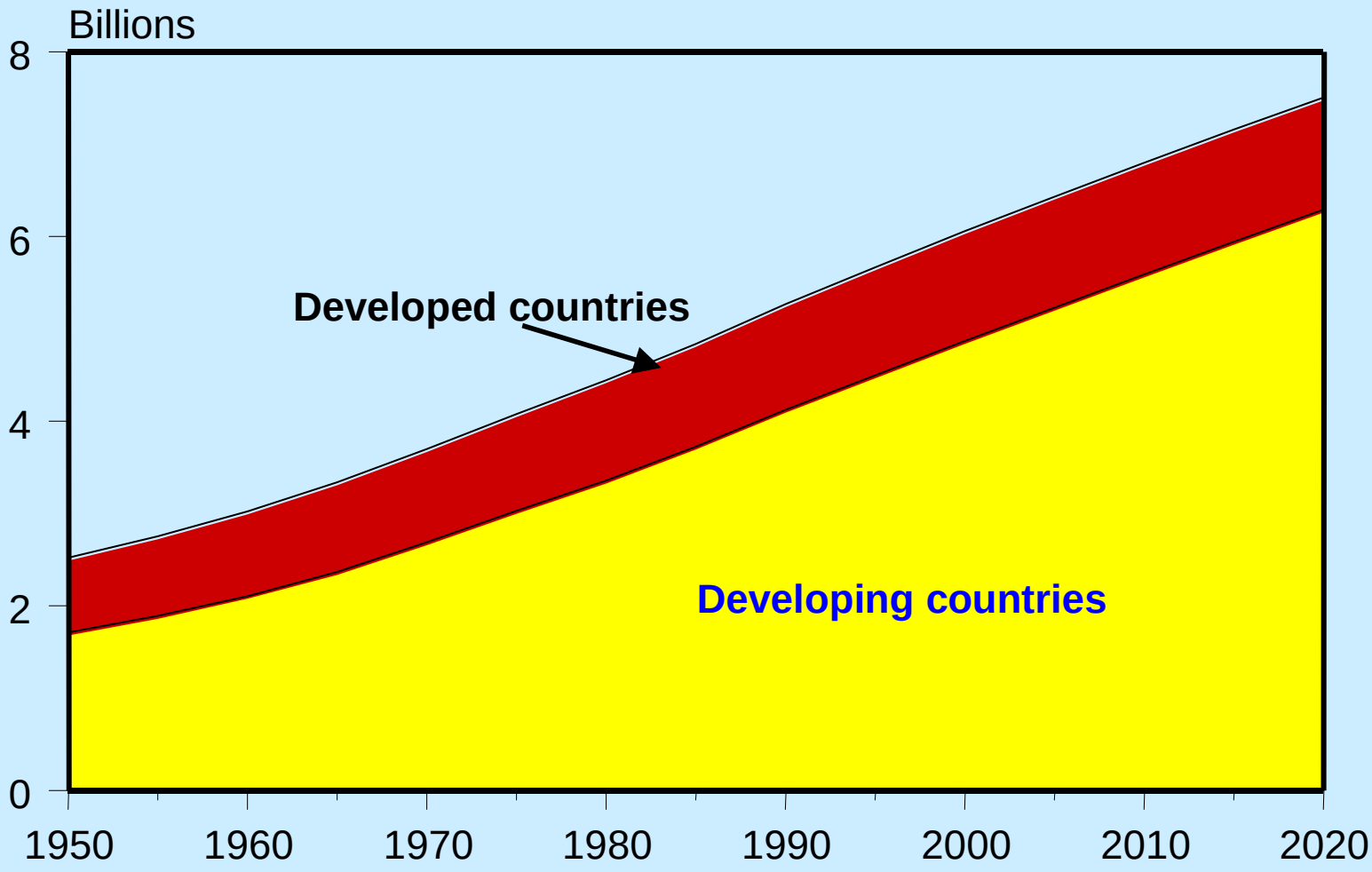
Role of the Food System

- To provide the necessary calories and nutrients to meet the needs of every person, permitting healthy and productive lives.
- To do so in a sustainable way

UN Universal Declaration of Human Rights, 1948

"…everyone has the right to a standard of living adequate for the health and well being of himself and his family, including food…"

World population, 1950-2020



Source: United Nations, *World population prospects: The 1998 revision* (New York: UN, 1999).
Note: Medium-variant projections for 2000-2020.

Enough calories for all now and by 2020
(if evenly distributed)

Year	Kcal/person/day
2000	2,800
2020	3,000

Hidden Hunger

- 250 million children worldwide are at risk for vitamin A deficiency
- 200 million people have goiter, 20 million are retarded as a result of iodine deficiency
- Nearly 2 billion people are iron deficient

New Paradigm for Agriculture

"An agriculture which aims not only for productivity and sustainability, but also, for balanced nutrition, or what we call the *productive, sustainable, nutritious food systems paradigm."*

Graham, Welch, & Bouis. 2001

How can we alleviate hidden hunger?

Iron as an example

Iron Fortification: The Need

- Iron Deficiency
  - Still a problem in U.S. in spite of 60 years of fortification/enrichment
  - Most prevalent micronutrient deficiency worldwide

Iron Deficiency

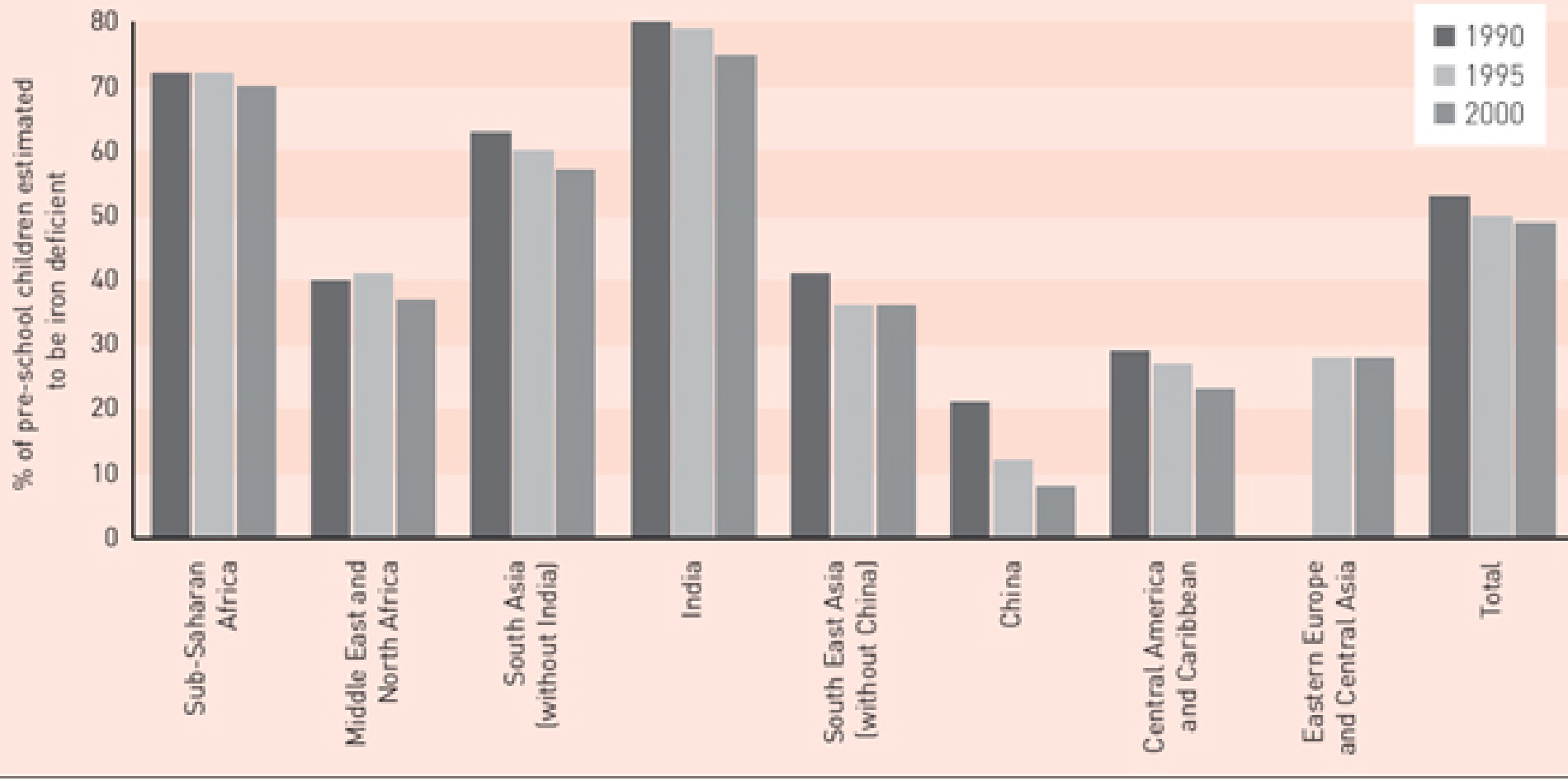
- Prevalence in U.S.
  - 9% of children aged 1-2
  - 9-11% of women aged 12-49
  - 1% of adult males

Prevalences of Fe deficiency anemia in children under 5

Country	Prevalence (5)
Brazil	45
China	8
Ethiopia	85
Nicaragua	47
India	75
Peru	50
Viet Nam	39

Unicef and MI, 2004

FIGURE 6
PREVALENCE OF IRON DEFICIENCY IN PRE-SCHOOL CHILDREN, BY REGION, 1990-2000



Unicef & MI, 2004

Strategies to Reduce Iron Deficiency

- Modification of diets:
  - Diversify diets to ensure adequacy
    - Increase Fe absorption enhancers
    - Decrease Fe absorption inhibitors
- Iron fortification of staple foods
- Iron supplementation
- Nutritional enhancement of foods through plant breeding and/or genetic engineering

Iron Fortification

- Advantages
  - Levels readily controlled
  - Proven effective
  - Relatively inexpensive
    - Cost = 12 U.S. cents/person/year
    - $0.12 x 2 billion people = $240 million/year

Iron Fortification

- Disadvantages
  - Requires centralized food processing
    - Does not reach subsistence farmers
  - Requires regulation and monitoring
  - Requires continuous effort and expense
  - May cause color and flavor changes
  - Bioavailability may be low

Iron Biofortification

- Enhancing the iron content of foods through:
  - Conventional Plant Breeding
  - Genetic engineering (biotechnology)

Enhanced iron and zinc accumulation in transgenic rice with the ferritin gene.

Vasconcelos M et al. Plant Science. 2003; 164:371-378

Fe and Zn in Transgenic and Control Rice (IR68144)

Sample	Iron (μg/g)	Zinc (μg/g)
Line 1	17.1 ± 1.1^{b}	$36.2 \pm .02^{b}$
Line 2	27.9 ± 1.0^{a}	55.5 ± 2.7^{a}
Line 3	21.3 ± 2.3^{a}	41.5 ± 5.4^{a}
Line 4	34.1 ± 46.8^{a}	46.8 ± 0.2^{a}
Control	15.7 ± 0.1^{b}	33.6 ± 0.2^{b}

Biotechnology

What is it?

Biotechnology

- The use of biological organisms in any technical application
  - Yeast for baking or brewing
  - Bacteria for culturing yogurt
  - Fungi in cheese, tempeh, miso

Genetic Engineering

- A subset of biotechnology
- Alters the properties of organisms by:
  - Transferring individual genes between organisms
  - Modifying a gene within an organism
- Can include:
  - Turning a gene on or off
  - Correcting a defective gene
  - Moving a gene to a different host

Transgenic Organisms

- Plants or animals that contain genes from another species are called transgenic.

Genetically Modified Organisms

- “GMOs”
- Virtually all of our animals and crop plants have been genetically modified
- Popular definition: organisms that have been modified through genetic engineering

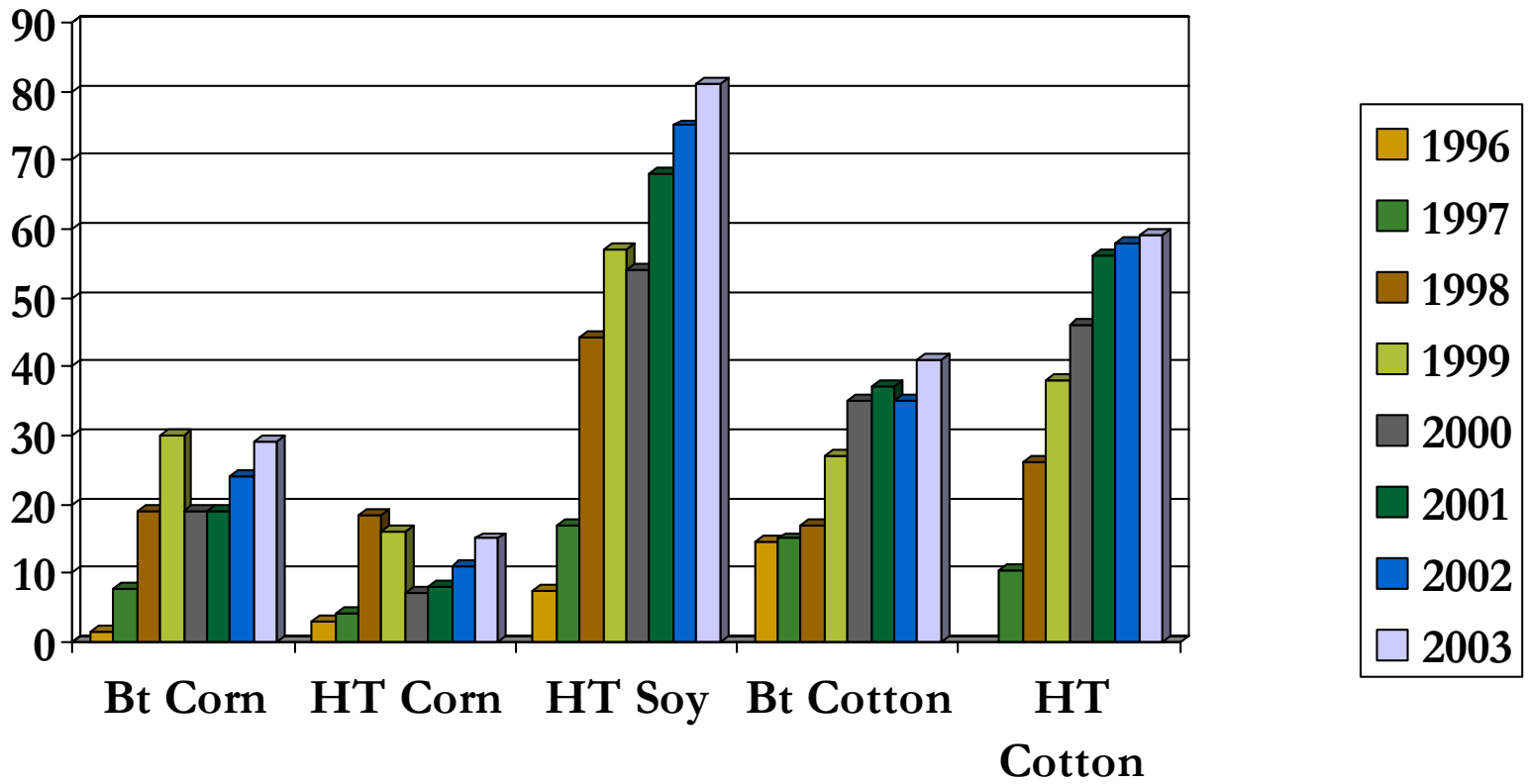
Use of transgenic crops

- Major players
  - U.S.
  - Canada
  - China
  - Argentina
  - Brazil ?

Global Acreages

- 2003: 167.3 million acres
- 2003 15 % higher than 2002

Percentage of U.S. Acreage in Genetically Engineered Crops



What foods contain GE crops?

- 60-70% of supermarket foods contain GE ingredients
- Products made with soy or corn most obvious
- Products with soy or corn derivatives
- Very little fresh produce

Environmental Impacts

- Hotly debated
- Bt crops require less chemical fertilizer
- Herbicide tolerant crops
  - Glyphosate (Roundup®) degrades quickly
  - Allows low-till agriculture
- Gene flow
  - Super weeds

Moral and Ethical Issues

- The application of agricultural biotechnology may cause environmental damage, including loss of biodiversity.
- Is biotechnology therefore morally wrong even if its application improves accessibility to food?

Moral and Ethical Issues

- Agricultural biotechnology may be an important tool in efforts to increase crop yields, improve the nutritional value of foods, and generally to provide a more adequate and nutritionally adequate food supply for the world population.
- Are actions of opponents of biotechnology morally wrong because they increase suffering and death among the poorest of the world's poor?

Moral and Ethical Issues

- New technologies developed through scientific research almost always carry some risk.
- Do the potential benefits of agricultural biotechnology outweigh possible risks?
- Who should bear the risks and who should receive the benefits?

Practical and Economic Issues

- Many populations around the world are accustomed to highly polished, pure white rice.
- Will people therefore avoid Golden Rice because of its yellow color even if they know it is more nutritious for them and their children?

Practical and Economic Issues

- Some countries refuse to allow imports of genetically engineered crops because of perceived negative impacts on human health and the environment. Therefore, farmers who plant GM seeds may be cutting themselves off from lucrative export markets.
- This being the case, are governments justified in banning GM crops in their respective countries?

Pro Position

- The government should promote and distribute genetically engineered rice seeds (enhanced in iron and beta-carotene) to poor farmers in the district.

Con Position

- The government should promote commercial fortification (with iron and vitamin A) of the polished rice that is currently consumed by the population in the region rather than spend scarce resources on controversial GMOs.

Readings

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