
FEEDING THE WORLD CONFERENCE
LONDON 12 NOVEMBER 2008
Are GM crops fit for purpose?
If not, then what?
Feeding the World Conference 2008 is supported by the following organisations.
ORGANIC RESEARCH CENTRE
ELM FARM
Sheepdrove Organic Farm
ECOLOGIST
Friends of the Earth
GM FREEZE
the campaign on GM food, crops and patents
Slow Food UK
PRACTICAL ACTION

Conference November 12th 2008
QE2 Conference Centre, Westminster, London

Feeding the World – Are GM crops fit for purpose?
If not, then what?

The GM transformation Process Applied to Crops: A Basic Science and Technological Perspective

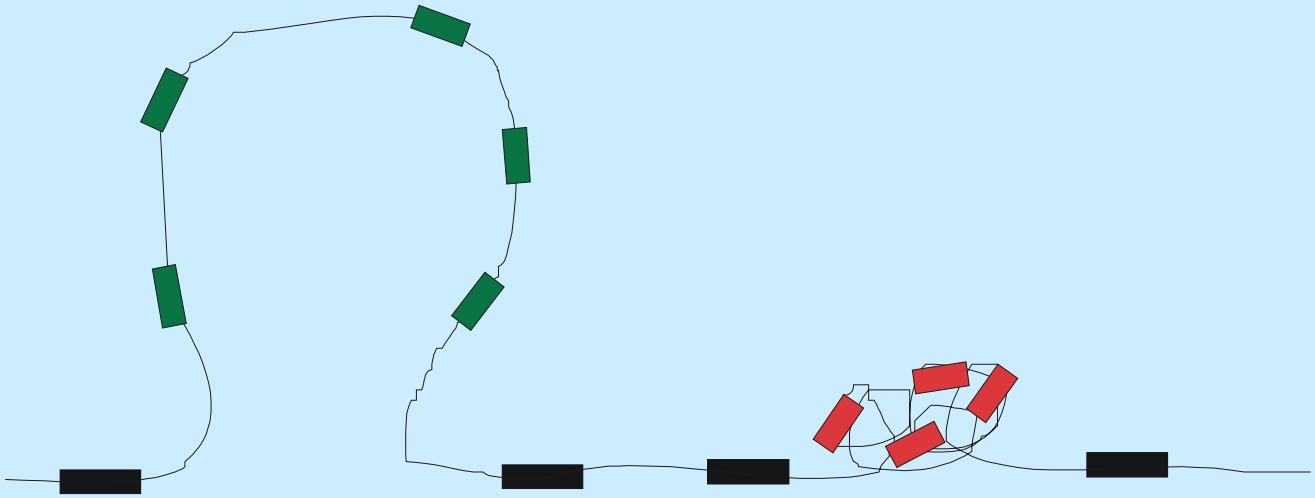
Michael Antoniou
King's College London School of Medicine,
Guy's Hospital, London

Central Tenets of Genetic Modification in Agriculture

The use of genetic modification (GM) in agriculture is a natural extension of traditional breeding methods but more precise and safer.

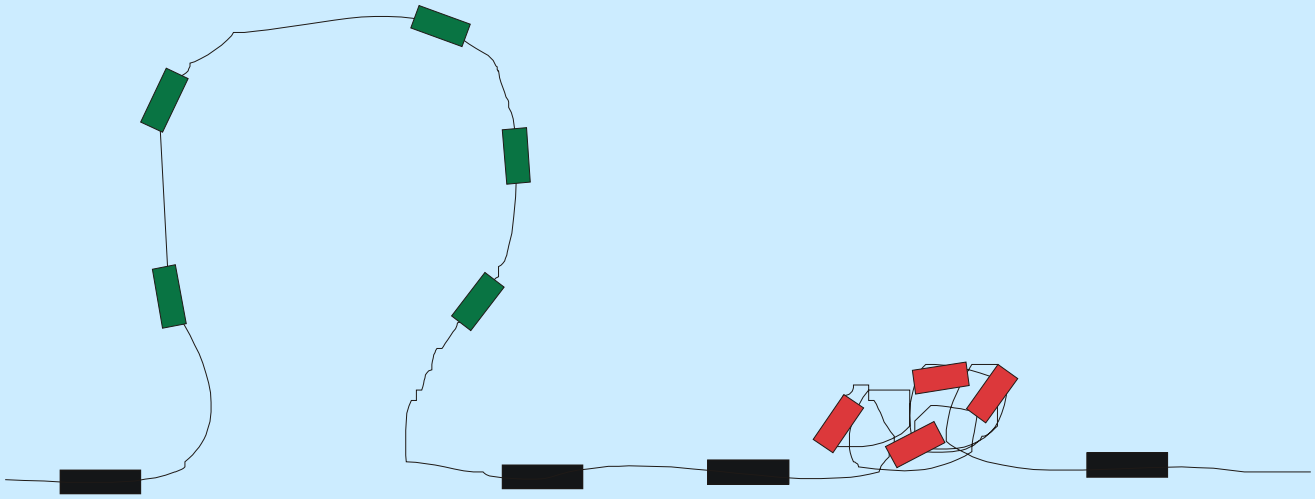
Genes are isolated units of information that can function in a totally predictable manner even when moved between unrelated species using GM technology.

Genes and Genetics - The Fundamentals
"The New Genetics"



1. Gene order/organisation in DNA is very precise.
2. In most cases, more than one RNA/protein is produced from a given gene.
3. Genes exist in groups or families.
4. Genes work in groups; no gene works in isolation.
5. Gene function is tightly regulated in a highly coordinated manner by both local and distant genetic elements and layers of epigentic control.
6. Genes have *co-evolved* to function together as an integrated whole within a given organism.

Genes and Genetics - The Fundamentals - “The New Genetics”



7. Normal sexual reproduction or breeding can take place only between closely related organisms. Genes are inherited in their natural groupings that have been finely tuned to work harmoniously together by millions of years of evolution.

Genes and Genetics - The Fundamentals
“The New Genetics”

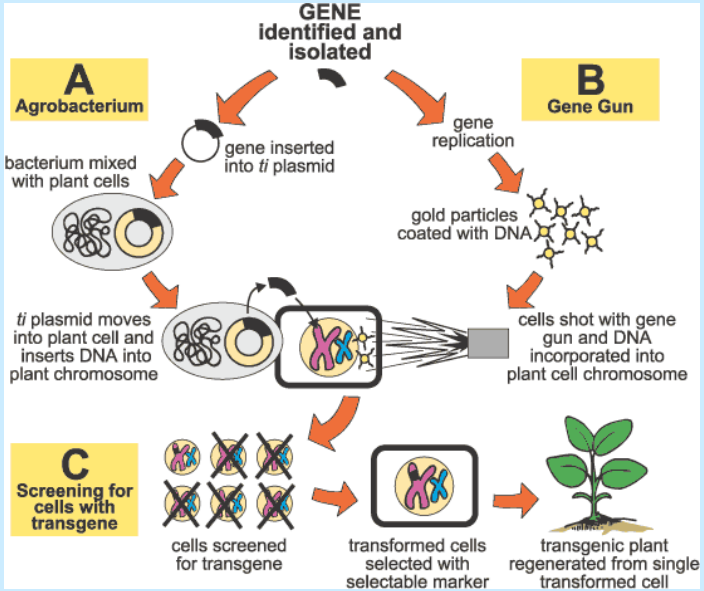
"In everyday language the talk is about a gene for this and a gene for that. We are now finding that that is rarely so. The number of genes that work in that way can almost be counted on your fingers, because we are just not hard-wired in that way."

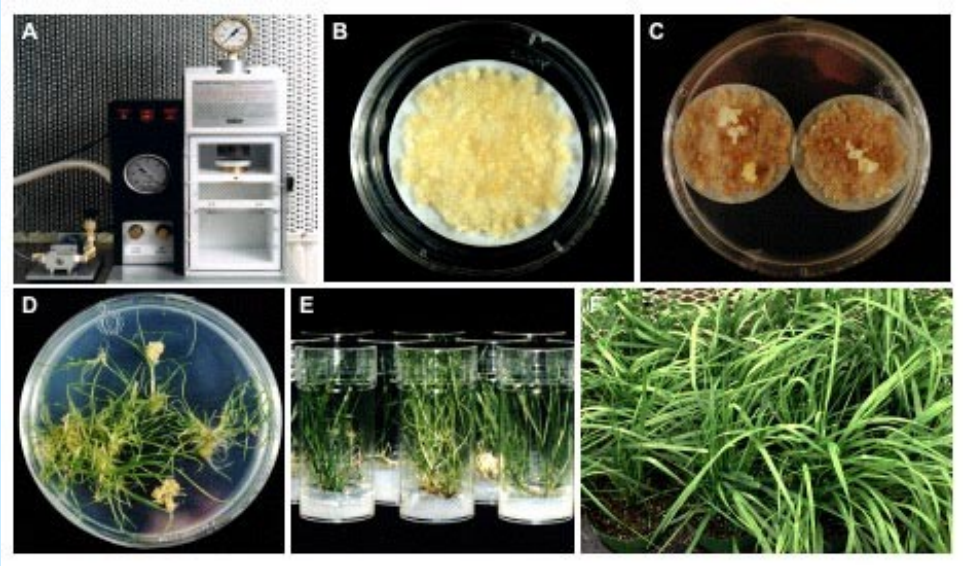
Craig Venter, Celera Genomics, 12 February 2001

Genetic Modification : The Fundamentals

- **New technology:** only ~27 years old.
- **GM allows the isolation and amplification of a gene of choice, in particular within a bacterial host organism:** this is the **"precise"** aspect of GM technology.
- **Does not involve natural sexual reproduction methods:** GMOs are laboratory "creations"; e.g. genes inserted into plant cells under laboratory culture using mechanical ("biolistics") or bacterial infection methods.
- **Allows transfer of one or few genes between totally unrelated organisms:** e.g. bacterial, viral or animal genes into plants.
- **Employs artificial combinations of genetic material:** e.g. Cauliflower mosaic virus/petunia genetic switch control elements linked to a bacterial gene inserted into soya beans to confer herbicide resistance.
- **The GM transformation process is very inefficient.** Only a very low percentage of plant cells take up the foreign gene cassette; antibiotic resistance genes have to be used to select for transformants.
- **Generation of GM plants (and animals) involves the *random* insertion or splicing of a foreign gene into the host DNA/genome.**
- **The GM transformation process as a whole (tissue culture plus gene insertion process) is highly mutagenic.**

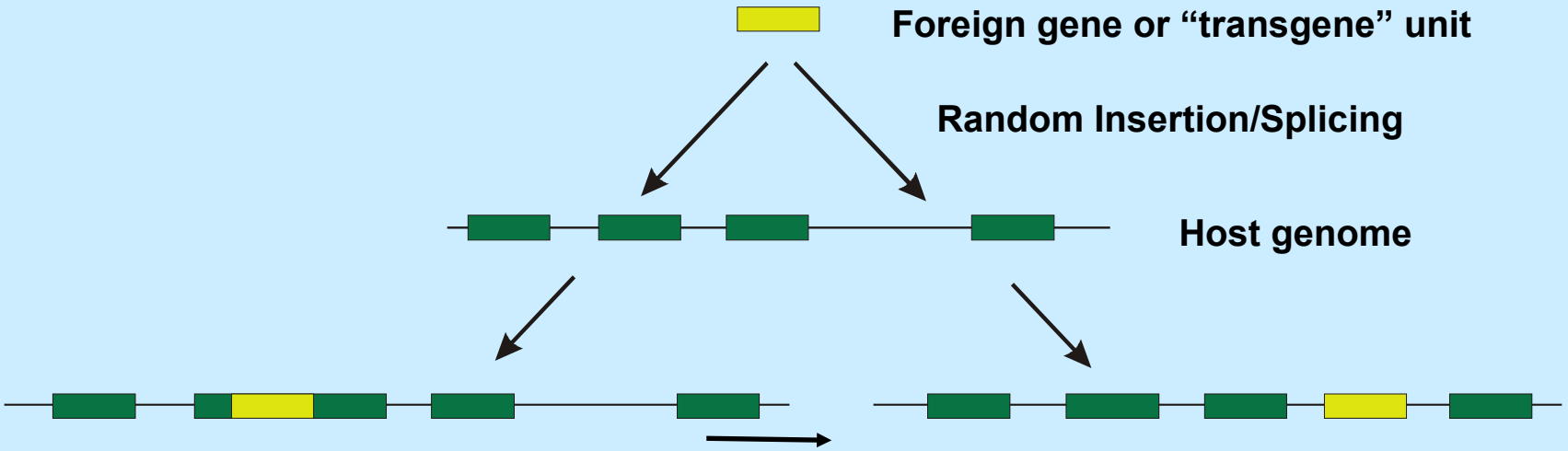
The GM Transformation Process





(A) PDS/1000 biolistic device used for microprojectile bombardment.
(B) Suspension cells of tall fescue plated on filter paper before microprojectile bombardment.
(C) Hygromycin resistant calli obtained after selection.
(D), **(E)** Transgenic plantlets regenerated from the hygromycin resistant calli.
(F) Transgenic tall fescue plants growing in the greenhouse.

Random insertion or splicing of a foreign gene into the host DNA/genome



GM gene insertion is not a “clean” process; deletions (loss) of host DNA at the site of GM gene insertion is common.

Disruption of host gene function at short/long distances
Variable GM gene function

The Mutational Consequences of Plant Transformation

Jonathan R. Latham, Allison K.Wilson and Ricarda A. Steinbrecher

Journal of Biomedicine and Biotechnology
Volume 2006, Article ID 25376, Pages 1–7

Tissue culture phase and gene insertion process combine to cause

"… genome-wide mutations can number from hundreds to many thousands per diploid genome. Despite the fact that confidence in the safety and dependability of crop species rests significantly on their genetic integrity, the frequency of transformation-induced mutations and their importance as potential biosafety hazards are poorly understood."

Consequences of GM in Plants

- **GM bears no resemblance to natural sexual reproduction and bypasses natural species barriers.**
- **GM brings about novel combinations of genes that have not evolved to function together.**
- **GM selects for foreign transgene insertion into active regions of the host genome.**
- **GM transformation process (transgene insertion plus tissue culture) is highly mutagenic.**
- **GM to a lesser or greater degree, always disrupts host genetic order and function.**
- **Transgene function is highly dependent upon site of integration within the host genome.** Note: most transgene promoter/enhancer elements employed are not subject to normal cellular control mechanisms and remain constantly "on" if inserted into a permissive "active" site.

- **These combined effects of GM can disrupt genetic and protein biochemical function leading to the generation of novel toxic effects, allergies and altered nutritional value.**

- **GM in agriculture possesses an unpredictable component that can frequently be greater than the intended change.**

GM Transformation can Interfere with Crop Performance and Reduce Yields

- Certain varieties of GM cotton suffered cotton ball and root development problems
- Certain varieties of GM cotton are more susceptible to nematode attack
- GM soya has a lower tolerance to heat
- GM soya has highly reduced uptake of manganese
- GM soya beans and oil seed rape have given consistently lower yields for more than a decade.
- Field trials show GM soya to have a 10% lower yield potential with 50% of the drop due to the genetic disruptive effect of the GM transformation process
- Field trials of Bt insecticide producing maize hybrids showed that they took longer to reach maturity and produced up to 12% lower yields

Potential Health Effects of GM Foods : Some Current Evidence for Unexpected Toxic and Allergenic Events

Extensive laboratory animal feeding studies with GM food raise worrying health concerns

- Rats fed GM tomatoes developed stomach ulcerations
- Offspring of rats fed GM soya had 4 times the death rate of rats fed non-GM soya
- Liver, pancreas, and testes functions were disturbed in mice fed GM soya
- GM peas caused allergic reactions in mice
- Rats fed GM oilseed rape developed enlarged livers, often a sign of toxicity
- Rats fed GM potatoes had underdeveloped brains, testes and livers, an enlarged pancreas, a compromised immune system, and pre-cancerous gut tissues
- Rats fed insecticide-producing GM maize grew more slowly, suffered problems with the function of their liver and kidneys, and showed higher levels of certain fats in their blood
- Rabbits fed GM soya showed enzyme function disturbances in kidney and heart
- Sheep fed Bt insecticide producing GM maize showed clear disturbances in the functioning of the digestive system of ewes and liver and pancreas of their lambs

Higher Conversion Efficiencies in Animals Fed Non-GM Soya

Feed Costs Analysis

Conversion Efficiencies--Germany		
Animal	kg feed/kg meat	
	GM Soy Meal	Non-GM Soy Meat
Young pigs	2.60 – 2.80	2.45 – 2.60
Older pigs up to 110 kg	2.80 – 3.00	2.60 – 2.80
Broilers	2.55 – 2.75	2.30-2.50

A group of farmers in Germany kept very careful records on feed use for their pig herds and broiler flocks for over 1 year. They compared results using GM soy meal and Non-GM soy meal. The conclusion was that the efficiency with which feed was converted into meat was greater with Non-GM feed than with GM feed.

Higher Conversion Efficiencies in Animals Fed Non-GM Soya

Feed Costs Analysis

Conversion Efficiency USA				
	Head	Average Feed Weight per Animal	Finish Weight Average per Animal	Feed Conversion Efficiency
		kg	kg	kg feed/kg meat
GM Soy & Maize	40	347.5	113.7	3.06
Non-GM Soy & Maize	29	334.6	119.1	2.81

A similar study was done by a farmer in the US. He compared weight gain over the full lifetime of a herd of 40 pigs fed feed containing GM soy and GM maize with 29 pigs fed Non-GM soy and Non-GM maize. Feed conversion ratios were significantly better for the animals fed Non-GM feed.

Potential Health Effects of GM Foods :

Some Current Evidence for Unexpected Toxic and Allergenic Events

GM foods are not more nutritious but instead can be toxic or allergenic

Evidence for disruption of core biochemical pathways of the host plant

- GM soya was found to have 12-14% lower amounts of cancer-fighting isoflavones than non-GM soya
- Oil seed rape engineered to have vitamin A in its oil had highly reduced vitamin E and altered oil-fat composition

- In the late 1980s, a food supplement produced using GM bacteria was toxic, initially killing 37 Americans and making more than 5,000 others seriously ill.

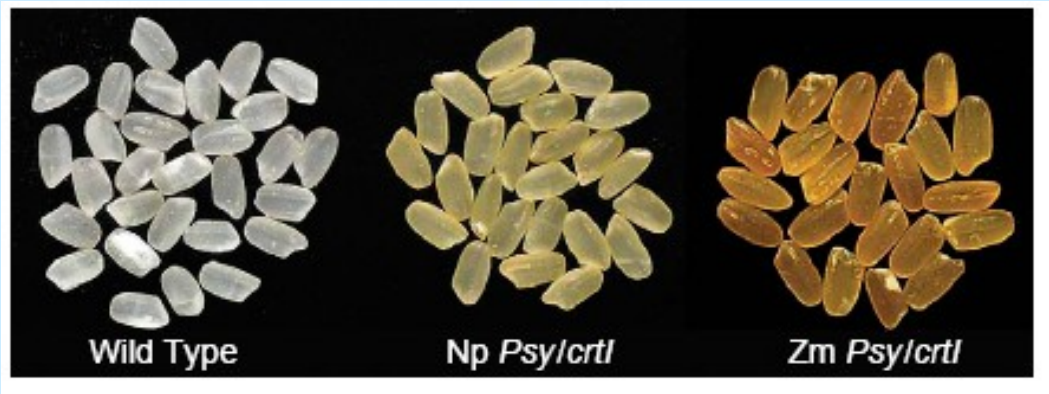
- People allergic to Brazil nuts had allergenic reactions to soya beans modified with a Brazil nut gene . (Not commercialised).

- **Starlink GM maize:** well-documented case examples of allergic reactions.

- **Golden (Vit. A) Rice ; Purple (high anthocyanin) Tomatoes ……?**

Nutritionally Altered GM Foods
An Unnecessary Risk

Enrichment of tomato fruit with health-promoting anthocyanins by expression of select transcription factors.
Butelli E et al. *Nat Biotech.* Published online 26 October 2008; doi:10.1038/nbt.1506



Improving the nutritional value of Golden Rice through increased pro-vitamin A content.
Paine JA et al. *Nat Biotech.* **23**: 482-487.

Looks good but what damage has the GM process done? The transcription factor GM genes used in the tomatoes are *not* selective in their effects!

The USA experience

- No baseline data - where did we start from?
- No labelling; no exposure data - who eats what?
- GM food ingredients at present account for only a small part of the US diet (maize, less than 15%; soya bean products less than 5%)
- No human feeding trials
- No official epidemiological data
- If GM food was causing changes to common conditions (e.g. allergy, auto-immune disease, cancer) there is absolutely no way that we could know!
- **Scientifically indefensible, uncontrolled experiment!!**

US Centers for Disease Control: food-related illnesses increased 2- to 10-fold from 1994 (just before GM food was commercialised) to 1999. Is there a link here with GM food consumption?

Meeting Future Food Needs : Tolerance to Abiotic Stresses

- **Heat Drought Salinity Flooding**
- **Yield potential**
- **.....**

Multi-gene functions:
Still being mapped in many crops; distributed in many locations in plant genome
Many patents on “drought ready” genes but still no applications

<u>Requirement:</u>
Transfer complex, tightly regulated arrays of genes that are at the basis of properties such as balanced enhanced nutrition, improved yield potential, pest and blight resistance, and tolerance to drought, heat and salinity cannot be reliably conducted by GM transformation.
“Probably no one has found the magic gene yet, probably there is no magic gene.” Jian Kang Zhu, professor of plant biology, University of California, Riverside. (New York Times, 23 Oct 2008)

More Effective and Safer Alternatives to GM

- Use of the tens of thousands of traditional varieties for each major food crop, which possess a wide range of food characteristics and agronomic potentials, including natural adaptation for tolerance to drought, heat, flooding, salinity, and a wide variety of pests and diseases. These are well adapted to harsher environments and marginal lands of the world.
E.g. African rice, pearl/finger millet, fonio, tef.
- Use of existing crop varieties and related wild relatives in traditional breeding programmes to develop varieties with enhanced characteristics useful in contemporary agriculture.
- Use of beneficial and more holistic ("systems biology") aspects of modern biotechnology, such as **Marker Assisted Selection (MAS)** to guide and accelerate the traditional breeding process. In contrast to GM, MAS has real potential to safely produce new varieties of crops with highly valuable, genetically complex properties such as enhanced nutrition, taste and yield potential, pest and blight resistance, and tolerance to drought, heat, salinity and flooding.

Biotechnology in Agriculture : A Better Way Forward

“Genomics and Marker Assisted Selection”

"GM is only one easily recognised by product of genetic research. The quiet revolution is happening in gene mapping ['genomics'], helping us understand crops better. That is up and running and could have a far greater impact on agriculture.... There really are no downsides, particularly in terms of public perception... "

Professor John Snape, John Innes Centre
'Gene mapping the friendly face of GM technology'
Farmers Weekly, 1 March 2002, p54

The Use of GM in Agriculture Summary

- GM is yesterday's technology based on yesterday's understanding of genetics.
- GM possesses inherent unpredictability for health and the environment which is currently impossible to quantify.
- The release of viable GMOs into the environment is not justified and possibly irresponsible as once released into the environment GMOs cannot be recalled.

There already exist proven alternatives to meet future food needs in a sustainable manner, a role that GM in its current form is unable to fulfil:

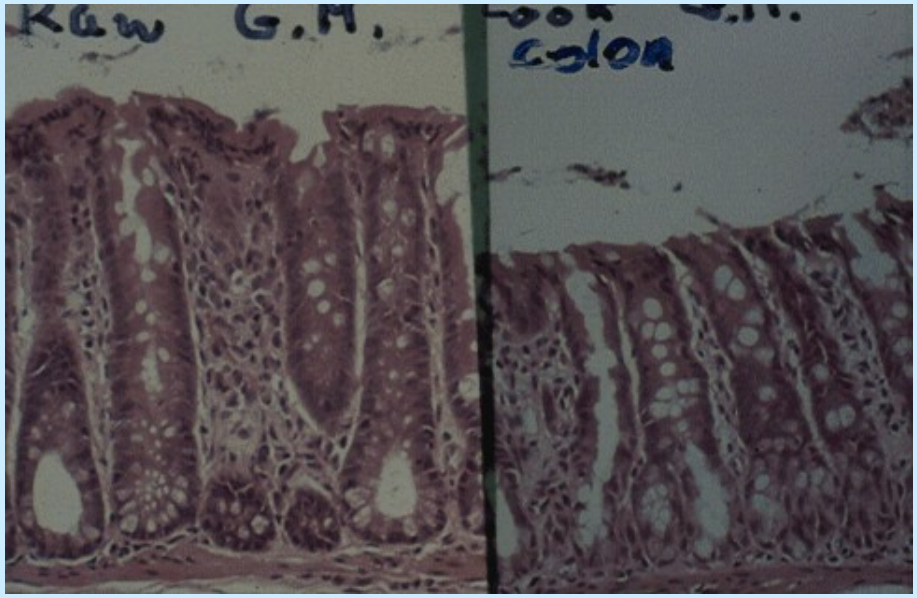
"Genetic-modification technologies just treat the symptoms rather than dealing with the causes", Hans Herren, president of the Millennium Institute, Arlington, Virginia (USA); co-chair of the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD). [*Nature,* **455**: 850-852, 2008].

Potential Health Effects of GM Foods :

Some Current Evidence

Mitogenic effect on gut mucosa?

Ewen SWB and Pusztai A, *Lancet*, **354**, 1353-1354, 1999 - GNA potato.



GM Non-GM

Rat Colon

GM peas cause surprise allergic reaction

26 November 2005

From New Scientist Print Edition.

http://www.newscientist.com/channel/health/mg18825274.100.html;jsessionid=MHKJPOCLMGEE

Prescott VE et al., (2005) *Journal of Agricultural and Food Chemistry*, 53: 9023-9030

Transgenic Expression of Bean α-Amylase Inhibitor in Peas Results in Altered Structure and Immunogenicity

Unexpected post-translational modifications on bean α-amylase inhibitor in peas caused massive immune response and allergic type reactions in mice.

Note: Starlink maize incident

MON863 GM maize causes haematological disturbances and and organ weight loss in rats

Only a 90-day feeding study comparing GM and non-GM equivalent diets showed significant changes in their blood cells, livers and kidneys, which might indicate disease.

Review of Some of the Significant Differences:

Measure	Function	Might indicate	Comments
Increased Basophil Counts	Creates histamine	Allergic reaction	Other Bt corn studies suggest possible allergic reactions.
Increased Lymphocytes and white blood cells	Immune reactions to fight infections, etc.	Infections, various toxins and diseases	Researchers omitted tests to see if the spleen, which creates lymphocytes, was affected.
Decreased Reticulocytes	Becomes mature erythrocytes (red blood cells)	Anemia	5% variability is allowable. Astoundingly, Monsanto claimed a 52% decrease was "attributable to normal biological variability."
Decreased Kidney Weight	To clear waste products	Blood pressure problems	Any inadequacy in kidney function is potentially life threatening.
Increased Blood Sugar	Essential energy source		A 10% elevation cannot be written off as insignificant, given the diabetes epidemic.

GM can Disrupt Core Biochemical Pathways of the Host

In an attempt to increase carotene (Vit A) in rape seed oil, a bacterial phytoene synthase (crtB) gene was overexpressed in a seed-specific manner.

Results:

- **50-fold increase in carotenoids in the seeds.**

- **Significant decrease in tocopherol (Vit E)**
- **Fatty acid composition significantly altered.**
- **Chlorophyll levels reduced in developing seed.**

Shewmaker CK et al. (1999) *Plant J* 20: 401-412.
(Calgene & Monsanto Labs)

[Golden (Vit. A) Rice ; Purple (high anthocyanin) Tomatoes ……?]

GM Soy Disturbs Cell Nuclear Structure/Function

Mice fed GM soya showed:

Disturbances in nuclear structure and function in:

Hepatocytes
pancreatic acinar cells
testes Sertoli cells

Pancreatic acinar cell zymogen synthesis and processing

Studies by Prof Manuela Malatesta, Italy

Did GM Bacteria Cause EMS?

L-tryptophan produced from GM bacteria linked with novel disease - eosinophilia-myalgia syndrome - EMS (USA, July - December 1989).

The total epidemic cases have been estimated at 5,000 - 10,000.

~1500 permanent disabilities; 38 deaths.

Was purification or the GM process to blame or both?

Substantial Equivalence

General biochemical analysis only.
Assessment of *known* toxins/allergens only.

GM and non-GM parental plant are "substantially equivalent" if they contain similar amounts of biochemical components within limits of natural variation.

No feeding trials required if they substantial equivalence is found.

FLAWS: Only looks at gross biochemical composition; only looks at known components.

NOTE: GMO-derived riboflavin and tryptophan.


More resources
available at the website
www.feedingtheworldconference.org
FEEDING THE WORLD CONFERENCE
LONDON 12 NOVEMBER 2008
Are GM crops fit for purpose?
If not, then what?
Feeding the World Conference 2008 is supported by the following organisations.
ORGANIC RESEARCH CENTRE
ELM FARM
Sheepdrove Organic Farm
ECOLOGIST
Friends of the Earth
GM FREEZE
the campaign on GM food, crops and patents
Slow Food UK
PRACTICAL ACTION