Advances in data requirement for safety assessment: A global perspective

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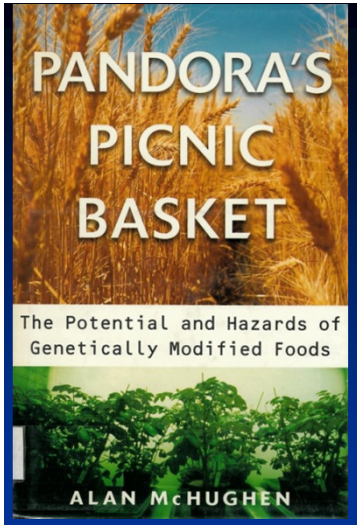
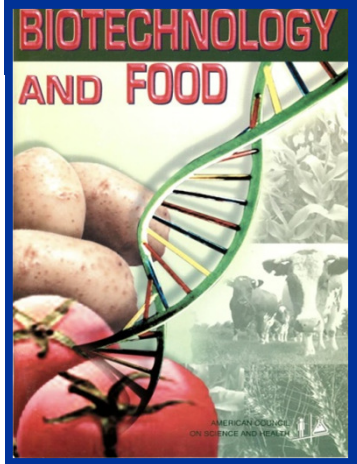
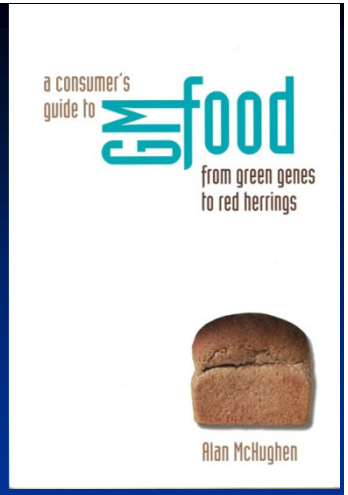
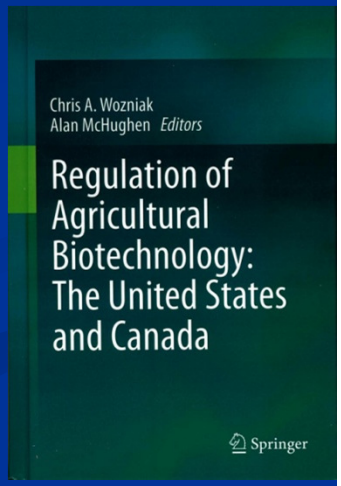
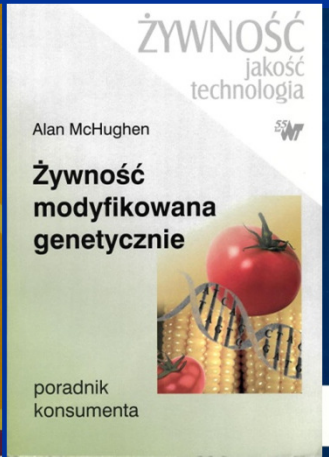
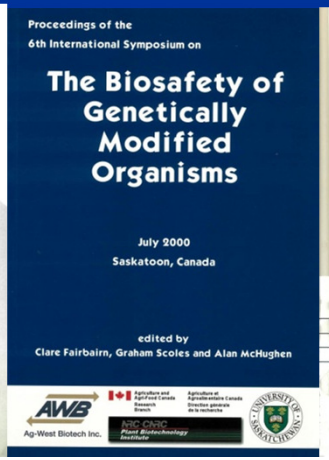


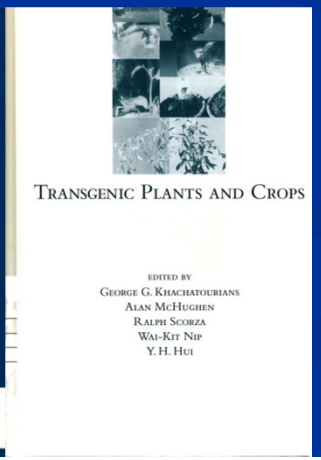


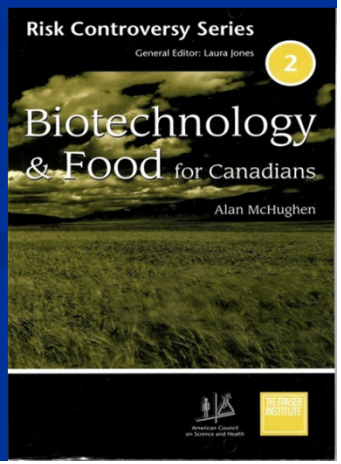












Some GE Products

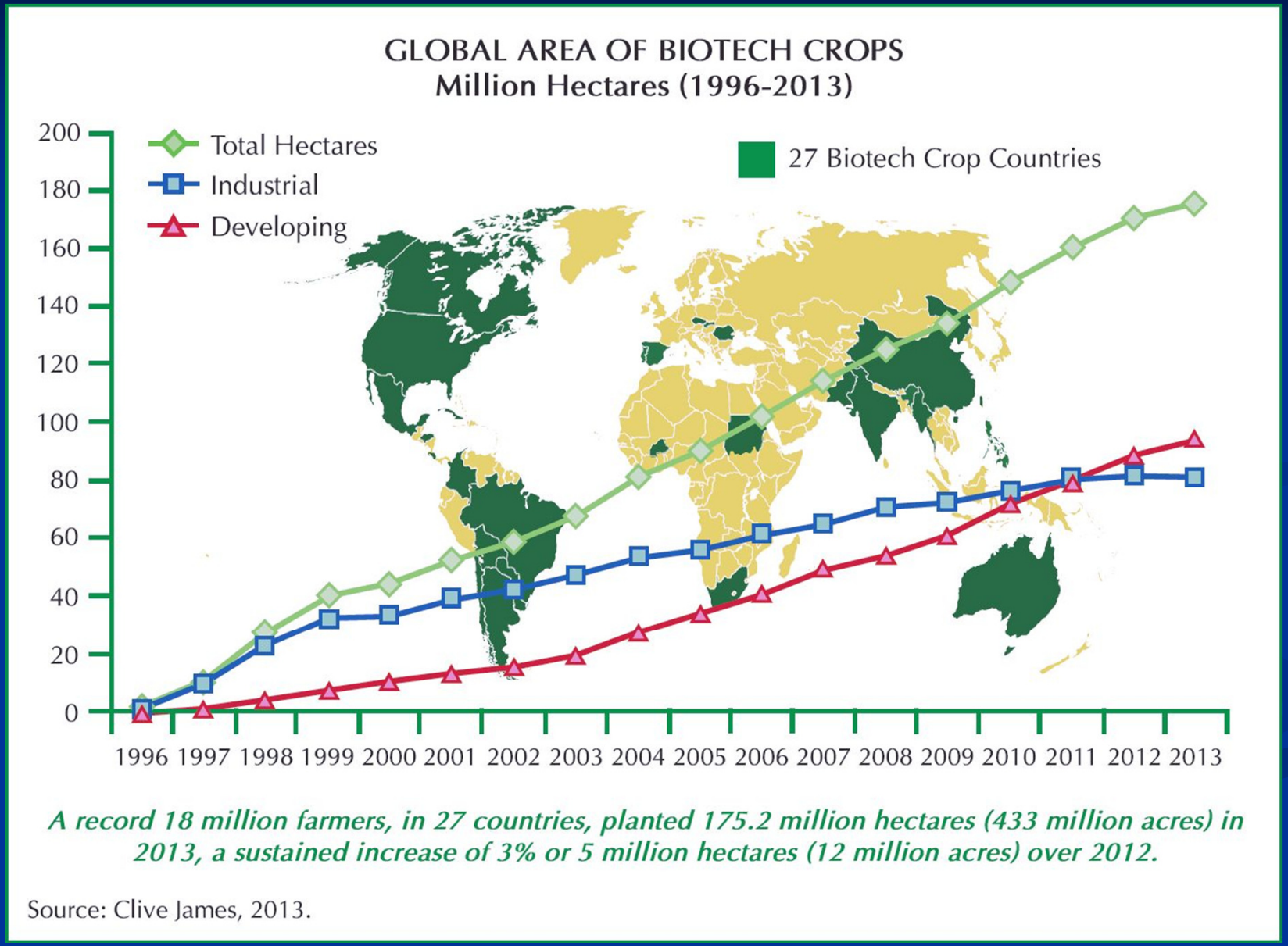
- Human insulin (since 1978, FDA 1982)
- Chymosin (since 1986, FDA 1990)
- Flavr-Savr™ Tomato (FDA 1994- 1997)
- Virus resistant Squash (FDA 1995)
- Virus resistant Papaya (1991, USDA-1998)
- Others (mostly purified, no GE ingredients in food): corn, soy, canola, cotton, alfalfa, sugar beet
- *Also*: A multitude of GE drugs, vitamins, additives.

Status of GE crops

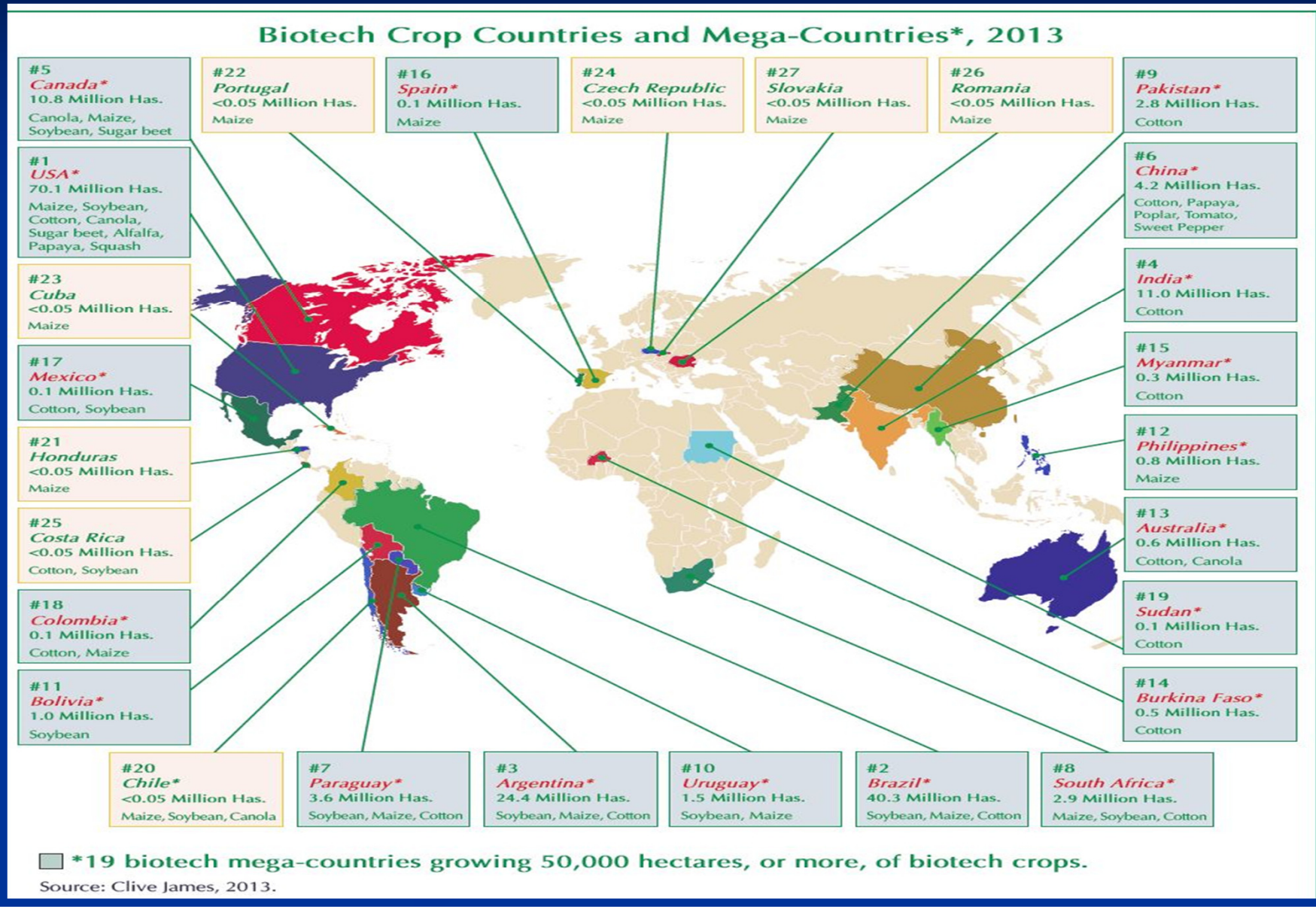
- USA
  - Corn > 93%
  - Cotton > 96%
  - Soybean > 94%
- Argentina: Soybean > 90%
- Canada: Canola > 90%
- India: Cotton > 90%

Farmers worldwide support GE technology!

Year by year growth of GE crops



Global distribution of GE crops



Bangladesh 2014

- Bt Brinjal approved for commercial cultivation
- Brinjal is self pollinating and seeds are fertile
- Legally, seeds from Bt brinjal may NOT be saved, transported and grown elsewhere
- Biologically, seeds from Bt Brinjal CAN be saved, transported and grown elsewhere
- Look for them to appear soon in India.

Forced Legalizations of Crops

- Canada, 1984: CPS- HY320 Wheat (*non-GMO*)
- India, 2002: Bt Cotton (*11,000 hectares in Gujarat*)
- Brazil, 2003: GE Soybean (*from Argentina*)
- Eastern Europe- various GE crops
  - Ukraine 2013: Cultivation of GE crops is illegal
  - 15% of Maize crop is GMO
  - 30% of Soybean crop is GMO
- ? India, 2014: Bt Brinjal (*from Bangladesh?*).

Risk Assessment for Safety

- Scientific
  - Food and feed safety
  - Environmental safety
  - Safety scrutiny should focus on risk factors
  - Degree of scrutiny should be commensurate with risk
- Non Scientific
  - Political
  - Socio-economic
  - Philosophical, etc.

Theory of Risk Assessment

- Science based risk analyses
  - Other factors applied later
- Product vs process
  - Are rDNA processes are inherently risky?
  - Any process may result in risky products
- Scientific approach to risk *assessment* is global
  - Food safety is common to all
  - Environmental safety may vary by region
- But the **trigger** for regulatory action varies.

Fallacy of the EU process trigger

- EU definition of GMO 2001/18/EC:
  - (2) "*genetically modified organism (GMO)" means an organism, with the exception of human beings, in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination*;
  - (Some exceptions: mutagenesis, wide crosses)
- Products arising from a GMO trigger regulatory approval under EC Reg. No 1829/2003
  - *Food produced from or containing ingredients produced from GMOs*
  - Includes and captures sugar, oil, etc. from GM plants, even though there is no GM DNA or protein 'residue'.

Fallacy Illustration: *GM sugarbeet*

- GM sugarbeet plants undergo Photosynthesis
- Sucrose (sugar) is sequestered and stored in the tuberous root
- Upon harvest, the sucrose of extracted and purified, packaged and sold to consumers.
  - Only trace amounts of DNA or protein remain

  Yet the sugar is subject to EU approval prior to sale
- Other products from (GM) plant photosynthesis
  - $6CO_2 + 6H_20$ (light) → $C_6H_{12}O_6$ (sugar) + $6O_2$
  - 1.6B hectares of GM crops worldwide since 1996 pumping unregulated O_2 into the atmosphere.

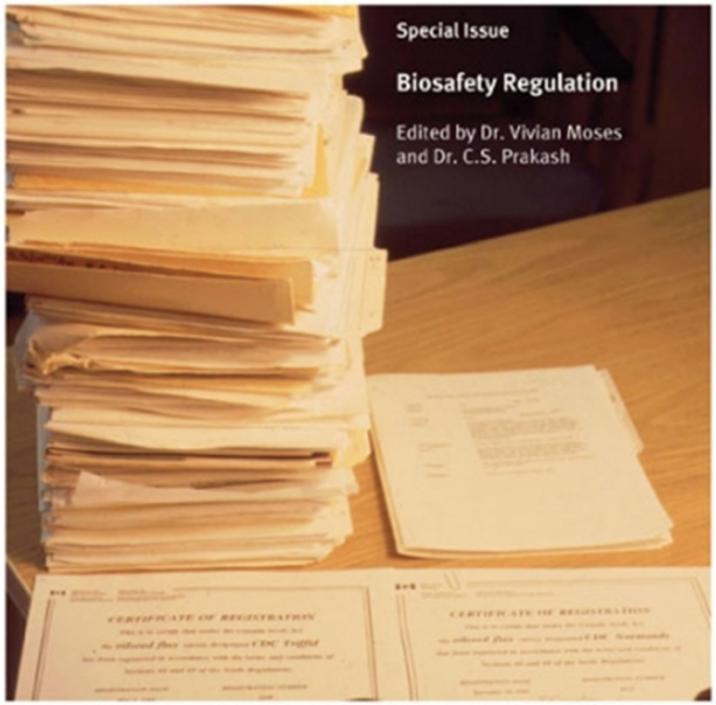
GE Crop Approval Data Requirements

- Agronomic performance
- Proximate analysis
- Antinutritive factors
- DUS
- *Plus:*

Risk assessment dossier for GE crop approval

- Molecular characterization of inserted DNA,
- Southern and restriction analyses
- PCR for several fragments,
- Various enzyme assays
- Copy number of inserts
- Size of each fragment,
- Source of each fragment
- Utility of each fragment
- How fragments were recombined
- How construct was delivered
- Biological activity of inserted DNA (genes)
- Quantitative analyses of novel proteins (western analyses)
- Temporal activity of inserted genes
- spatial activity of inserted genes
- complete amino acid analysis
- detailed amino acid analysis for intended proteins
- Toxicity (feeding trials not usually warranted)
- Allergenicity (feeding trials not usually warranted)
- Biological analysis of:
- Pathogenicity to other organisms
- dormancy,
- outcrossing
- potential for horizontal gene transfer
- seed production
- flowering time,
- flower morphology
- analysis of relatives
- stability of inserted genes over seed generations
- survivability in natural environment
- survivability in agricultural environment in presence of herbicide (for HT plants)
- survivability in agricultural environment in absence of herbicide (for HT plants)
- Interaction with other organisms- alterations to traditional relationships
- Interactions with other organisms- novel species
- Changes to persistence or invasiveness
- Any selective advantage to the GEO
- Any selective advantage to sexually compatible species
- Plan for containment and eradication in the event of escape

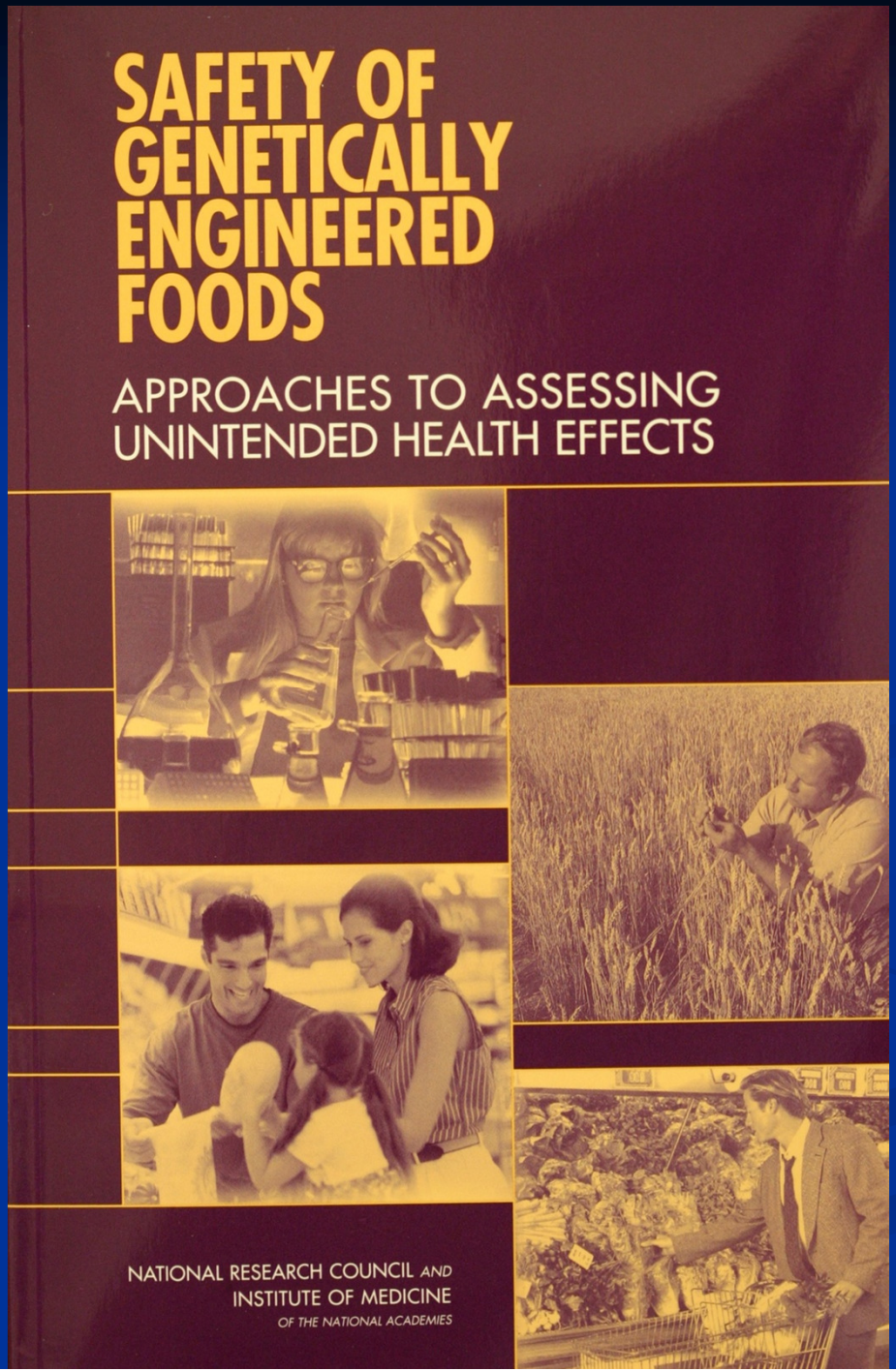
GM CROPS & FOOD
Biotechnology in agriculture and the food chain
Volume 3 • Issue 1 • January/February 2012

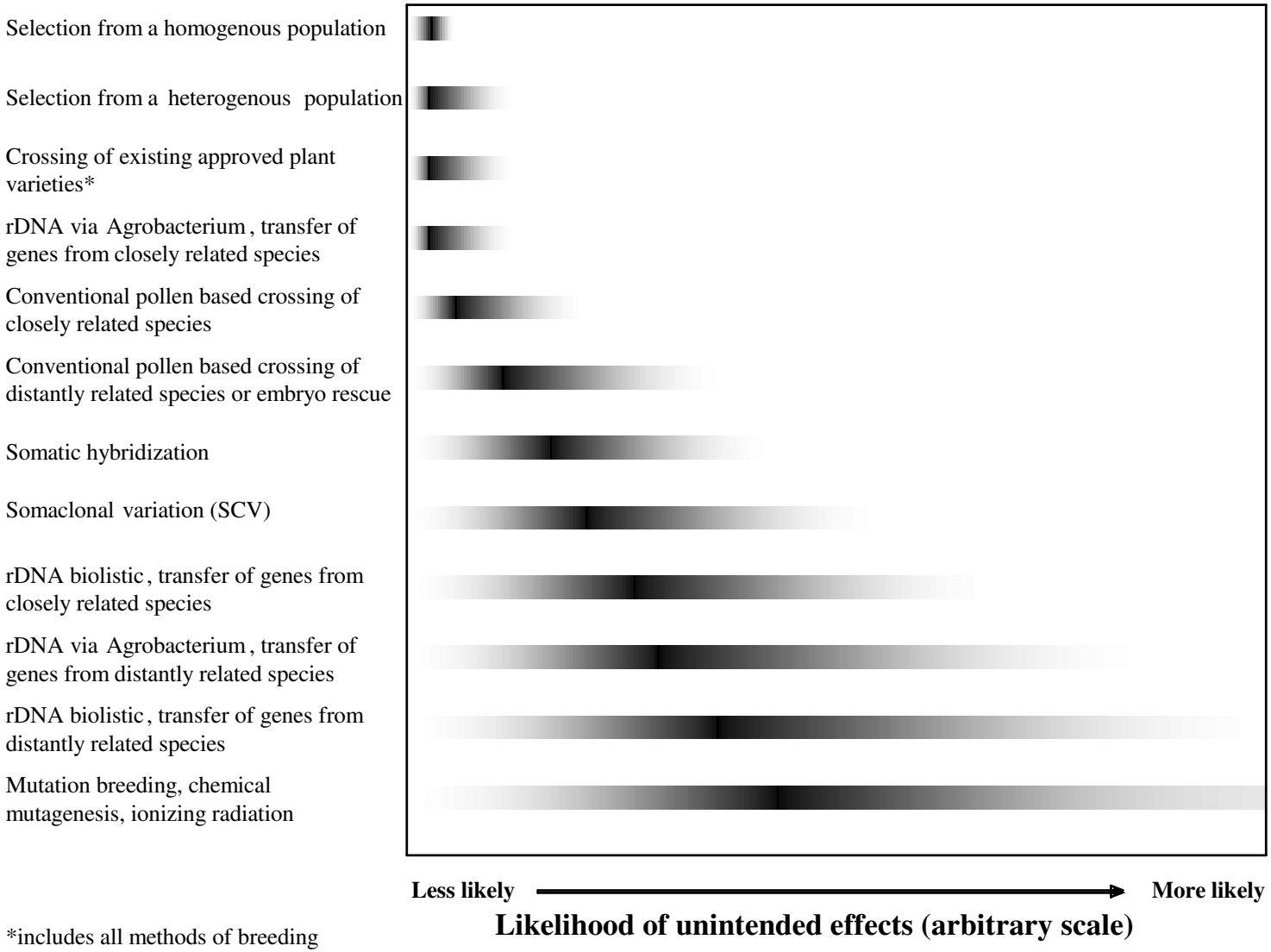


Comparison of the 1997 documentation required for the approval in Canada of GM-oilseed flax (on the left) versus its 'conventional' counterpart (right). Reproduced by courtesy of Professor Alan McHughen.

In this issue:

LANDES BIOSCIENCE


SAFETY OF GENETICALLY ENGINEERED FOODS
APPROACHES TO ASSESSING UNINTENDED HEALTH EFFECTS
NATIONAL RESEARCH COUNCIL AND
INSTITUTE OF MEDICINE
OF THE NATIONAL ACADEMIES



*includes all methods of breeding

NAS/IOM findings

- Genetic engineering is NOT inherently hazardous
- The risks of GE are similar to the risks posed by traditional forms of plant breeding
- There are NO documented adverse health effects from eating foods derived from GE crops.
  - Allegations of harm are plentiful, but all unfounded
  - Update: Still true as of July, 2014.

Food Safety Assessment

- **Hypothesis-driven**: What's new?
  - Don't conduct assays (e.g. animal tests) for fun
- **Focus:** Allergens, toxins and antinutritionals
- Characterize the substance
  - Protein? Carb? Fat? Mineral? Or what?
- Characterize dietary exposure
  - Paracelsus: 'Dosage makes the poison'
- Compare with known/traditional foods
  - Focus on differences
- Codex Alimentarius /OECD test protocols

Assurance of Safety

- Scientific studies overwhelmingly show the safety of GM foods and crops
  - Over 1,700 technical, peer reviewed studies in the literature, covering every aspect of GMO safety
  - Nicolia et al., 2013. Crit Rev Biotechnol. 1-12
  - http://www.biofortified.org/genera/
- The few studies purporting to show hazard have ALL been rejected on scientific grounds by the professional scientific and medical community
- "**No adverse health effects attributed to GE have been documented…**" *NAS 2004, AAAS 2013.*

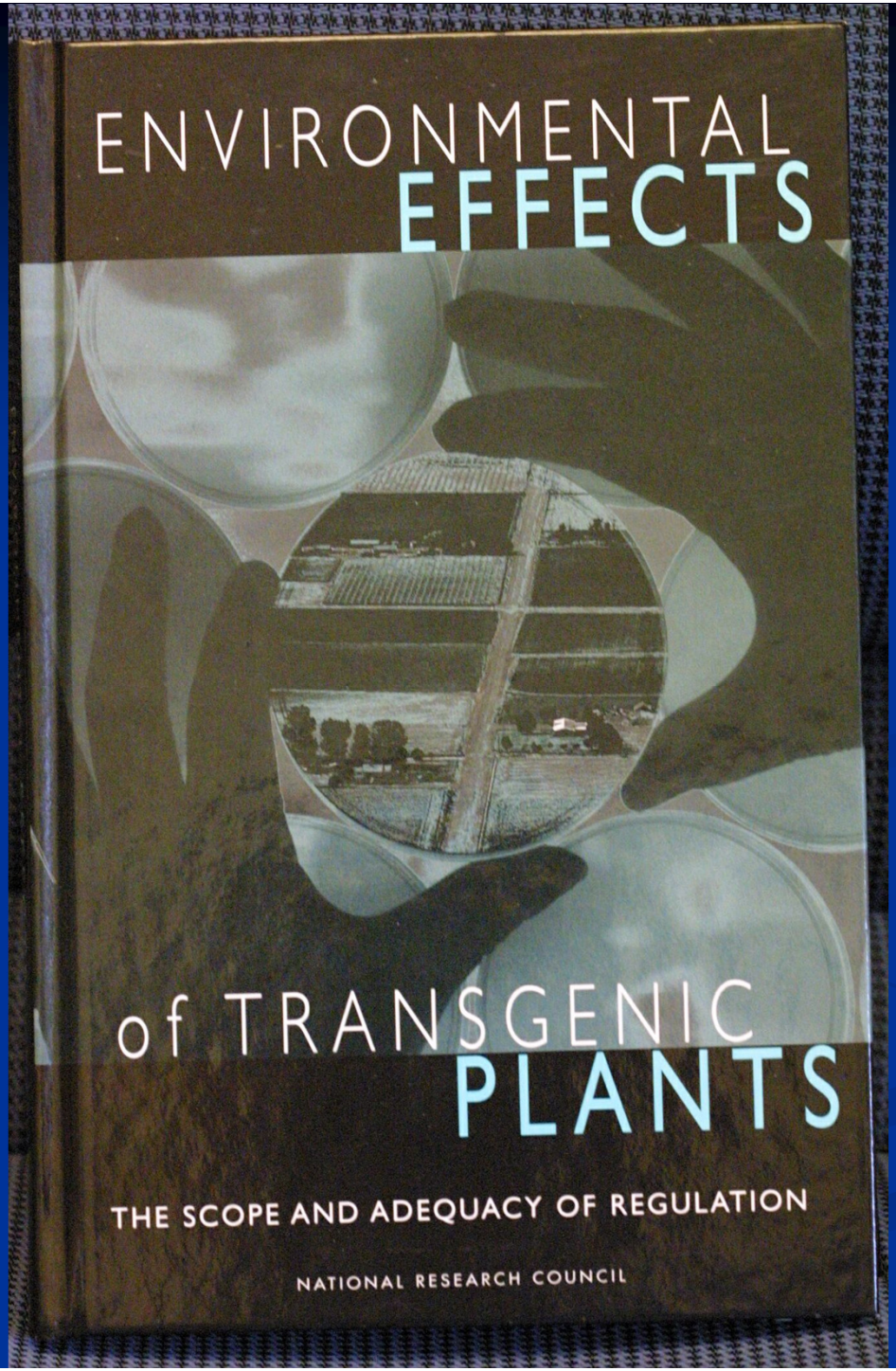
Scientific Consensus on Safety?

- **Generally positive**

* US National Academies
* US Institute of Medicine
* American Medical Association
* British Royal Society
* Royal Society of Medicine
* EFSA
* EU Economic Commission
* World Health Organization
* AAAS
* American Dietetic Association
* International Seed Foundation

Etc, etc…

- **Generally negative**


ENVIRONMENTAL
EFFECTS
of TRANSGENIC
PLANTS
THE SCOPE AND ADEQUACY OF REGULATION
NATIONAL RESEARCH COUNCIL

Ecological damage is correlated to:

- Process of breeding – No
- Amount of genetic change – No
- Source of new genetic material – Depends
- Species and Genotype altered – Yes
- Trait introduced – Yes
- Environment of new release – Yes

Environmental effects of GM Crops

- Inevitable: (Trans)Genes are going to escape
- Transgenes escape no more or less frequently than other genes (∫ host sp. and local environment)
- Mere presence of an escaped transgene does not imply health threat or environmental damage
- Interventions to detect transgenes at vanishingly smaller limits is irrelevant
  - in the absence of documented risk and specific hazard
  - or without relative context, e.g. Arsenic, biodiversity.

Relevance to risk assessment of transgenes into wild relatives

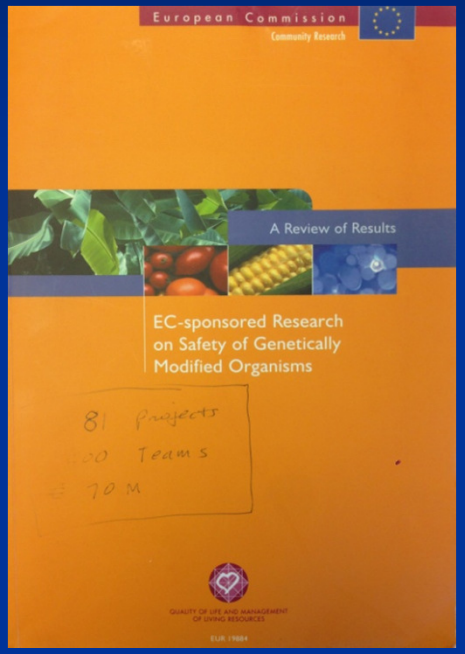
- Unless the transgenes enhance fitness in wild relatives, an introgression is unlikely to be detected
  - Unless the transgene reappears in a crop
- Fitness traits are not (yet*) in GM crops
- Fitness traits are not limited to transgenes
- Real threats to health and environment are functions of species, trait and region
- Method or process of genetic modification is irrelevant to health or environmental safety.

'Are GM crops safe for the environment?'

- Less pesticide burden
- Safer pesticides (residue, toxicity, etc)
- Improved soil from less tillage
- Less tractor fuel usage
- Increased biodiversity (more non-target species thrive)

  - Sources: NRC, US April 2010; USDA-ERS, 2014
  - NCFAP, Plant Biotechnology, June 2002; November 2004
  - Canola Council of Canada, An agronomic and economic assessment of transgenic canola, 2001
  - Munkvold, G.P., Hellmich, R.L., and Rice, L.G. 1999. Comparison of fumonisin concentrations in kernels of transgenic Bt maize hybrids and non-transgenic hybrids. Plant Dis. 83:130-138.
  - Wu, F. 2008. http://www.isb.vt.edu/news/2008/news08.Feb.htm

European Union
Gov't funded research on GM safety



1985- 2000:
81 projects
400 public scientific teams,
70,000,000 Euros

2000- 2010:
50 Projects
400 public scientific teams
200,000,000 Euros

Total: 25 years, 270M Euros

World Health Organization

- " no effects on human health have been shown as a result of the consumption of such foods by the general population in the countries where they have been approved."

- http://www.who.int/foodsafety/publications/biotech/20questions/en/

Conclusions

- Wherever farmers have been allowed to grow GE crops, they have been successful
- There is NO verified documentation of any harm, to either health or environment, due to approved GM crops and foods over 25 years
- Successful food, feed and environmental safety assessments use the same approaches as for other new products
- **There is NO need for additional safety data.**