Introduction to Opportunities in Plant Synthetic Biology

A GARNet meeting

21-22 May 2013

University of Nottingham

GARNet

Responsible research and innovation for synthetic biology

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CSynBI

Centre for Synthetic Biology and Innovation

What is Responsible Research and Innovation (RRI)?

1. **An emerging concept, still in the process of being defined**

2. **My ideas for the implementation of RRI for (plant) synthetic biology**

Unavoidable Fact:
Responsible Innovation has become a key concept promoted by UK research funders for synthetic biology

BBSRC
bioscience for the future

Investing in world-class bioscience research and training on behalf of the UK public

News and events | Research funding | Working with business | Science in society

May 2013

Home > Research funding > Special opportunities > 2013

Research funding:

- Strategic priorities
- Apply for funding

Multidisciplinary research centres in synthetic biology

This is a joint call with EPSRC

Scope

The multidisciplinary Synthetic Biology Research Centres (SBRCs) will possess the vision, breadth of intellectual leadership and research resources required to integrate disciplines including bioscience, engineering, chemistry and IT into programmes of synthetic biology research of the highest international quality.

They will also integrate the research activities of experimental scientists with those working on ethical, legal, societal and other issues within the context of responsible innovation.

The UK Roadmap for Synthetic Biology ....

...calls for a responsible innovation approach

Technology Strategy Board
Driving Innovation

... and we intend to support that ....

.... starting with this Feasibility Studies competition

Technology Strategy Board
Driving Innovation

Slides used in presentation of TSB Responsible Innovation Framework by Paul Mason at Feasibility studies competition briefing event on 15th October 2012

RRI will be a cross-cutting theme for the Horizon2020 European Commission research funding programme

Definition used by René von Schomberg at DG Research and Innovation of the European Commission (2011):

"Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)."

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An Outline Framework for Responsible Innovation

Report to the EPSRC by

Jack Stilgoe, Richard Owen and Phil Macnaghten, 2012

Definition of RI: "*Taking care of the future through collective stewardship of science and innovation in the present*"

Four proposed characteristics of RI:

1. **Anticipatory**
2. **Inclusive**
3. **Reflective**
4. **Responsive**

- Should occur alongside and within processes of research and innovation as these happen
- Focus on purposes, needs, alternatives

TSB Feasibilities Competition Responsible Innovation Framework

We encourage those involved in projects to

- ***Anticipate*** before work begins the *intended and potential unintended* impacts of the commercial use of the technology, including the potential for misuse.
- ***Reflect*** and identify on the outcomes of their proposed projects and identify any important knowledge gaps.
- ***Respond*** positively to the outcomes of this process.

... and to do this as an ongoing process

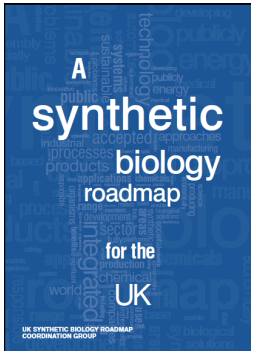
Slide used in presentation of TSB Responsible Innovation Framework by Paul Mason at Feasibility studies competition briefing event on 15th October 2012

Social scientists were appointed as members of the BIS-led UK Synthetic Biology Roadmap Coordination Group

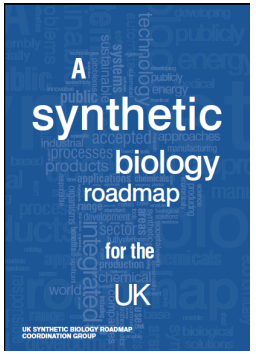
Nikolas Rose and Claire Marris, King's College London
Jane Calvert, Edinburgh University

Initially asked to contribute to section entitled "acceptability, regulatory and social"

We proposed changing the title of this header to "responsible research and innovation"



The vision of future synthetic biology envisaged by the UK Roadmap



Our vision is of a UK Synthetic Biology sector which is:

- economically vibrant, **diverse and sustainable**: where businesses have successfully developed and introduced and introduced new products, processes and services – leading to significant revenues and employment
- cutting edge: leading scientific advances and with a resilient platform of underpinning revenues and employment
- **of clear public benefit: an exemplar of responsible innovation, incorporating the views of a range of stakeholders and addressing global societal and environmental challenges** within an effective, appropriate and responsible regulatory framework.

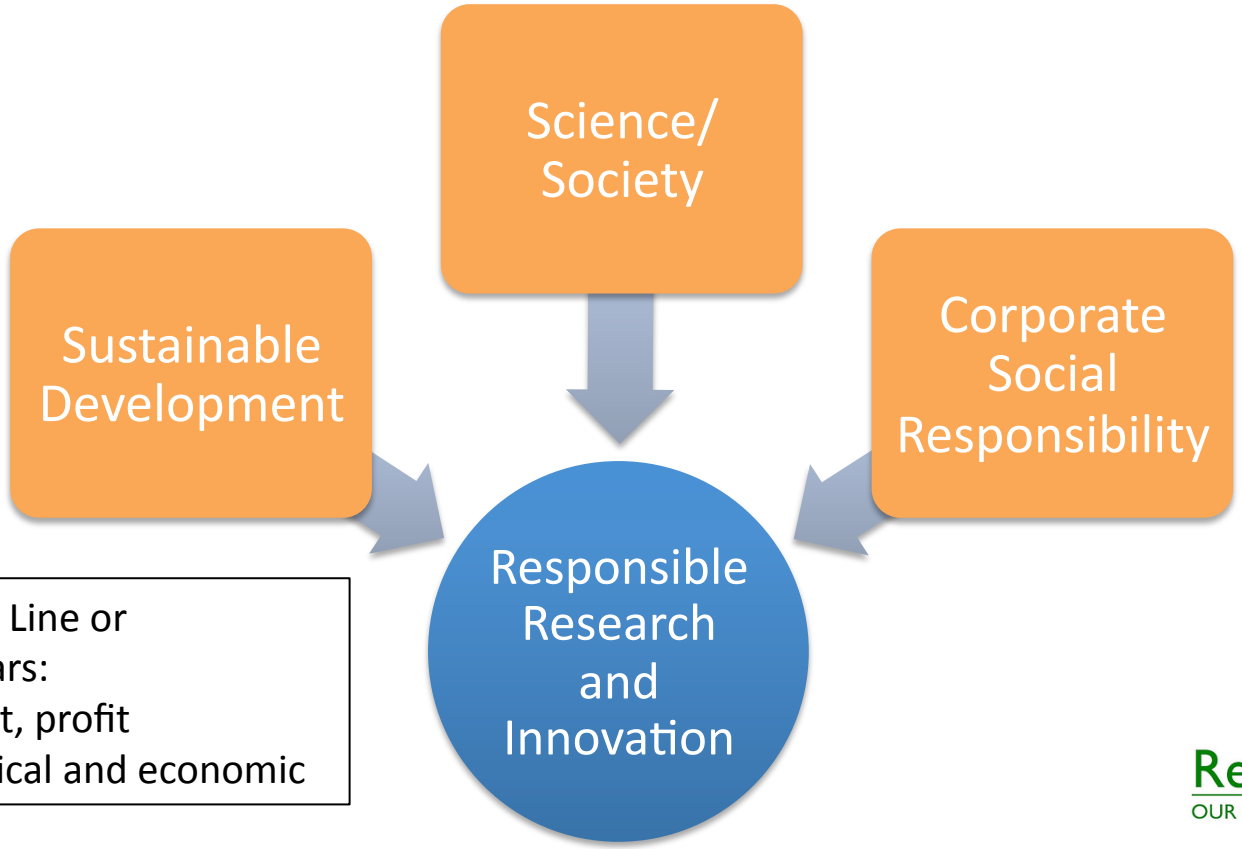
UK Synthetic Biology Roadmap

Five Core Themes	Five Recommendations
1. Foundational science and engineering	1. Invest in a network of multidisciplinary centres to establish an outstanding UK synthetic biology resource
2. Continuing responsible research and innovation	2. Build a skilled, energised and well-funded UK-wide synthetic biology community
3. Developing technology for commercial use	3. Invest to accelerate technology responsibly to market
4. Applications and markets	4. Assume a leading international role
5. International cooperation	5. Establish a leadership council

Recommendation 2.2:
Embedding responsible innovation.
Public sector investment in synthetic biology should take into account social, ethical and regulatory issues [...]. This will include on-going stakeholder engagement and dialogue with wider social groups.

Where did RRI come from?

- Ethical, Legal and Social Issues (ELSI)
- Ethical, Legal and Social Aspects (ELSA)
- Participatory technology assessment
- Anticipatory Governance
- (Upstream) public engagement
- Public dialogue



Triple Bottom Line or
the three pillars:
people, planet, profit
social, ecological and economic

Responsible Care®
OUR COMMITMENT TO SUSTAINABILITY

UK Synthetic biology: incorporation of ELSIs and social scientists from the start

"Synthetic biology is an inherently multi-disciplinary area that has a small but growing community of researchers in the UK. Input from the biological sciences, the physical sciences and engineering disciplines is essential in tackling the challenges that face the research community…

….whilst close collaboration with social scientists and philosophers is vital to understanding the complexity of ethical and societal issues associated with this topic."

(EPSRC Flashlight call for research proposals, 2009)

Seven ‘Synthetic Biology Networks’ established in the UK in 2008

£390k £390k £76k £35k

“Each network in Synthetic Biology is required to address ethical, legal and social issues (ELSI) as an integral part of its research; drawing upon expertise from the humanities and social science as appropriate.”

More than 200 researchers
from more than 20 UK universities involved.

More than 30 UK researchers from the social sciences,
humanities and bioethics enrolled.

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EPSRC Science & Innovation Award: £4.7M, January 2009-October 2014

KING'S College LONDON

Imperial College London

EPSRC
Engineering and Physical Sciences Research Council

EPSRC funded project

"An Infrastructure for Platform Technology in Synthetic Biology"

£5M, 5 years, 5 universities - the "Flowers Consortium"

Started July 2012

Imperial College London

King's College London

University of Cambridge

The University of Edinburgh

Newcastle University

One of 7 Objectives of the project is:

"To promote responsible innovation in synthetic biology"

Responsible Innovation is defined in grant as:

"the incorporation of ethical, societal and environmental considerations into synthetic biology design. For the members of the project consortium, responsible design is intrinsic to the operation of the systematic design cycle."

<u>Social scientists incorporated into grant:</u>

Nikolas Rose and Claire Marris at King's College London

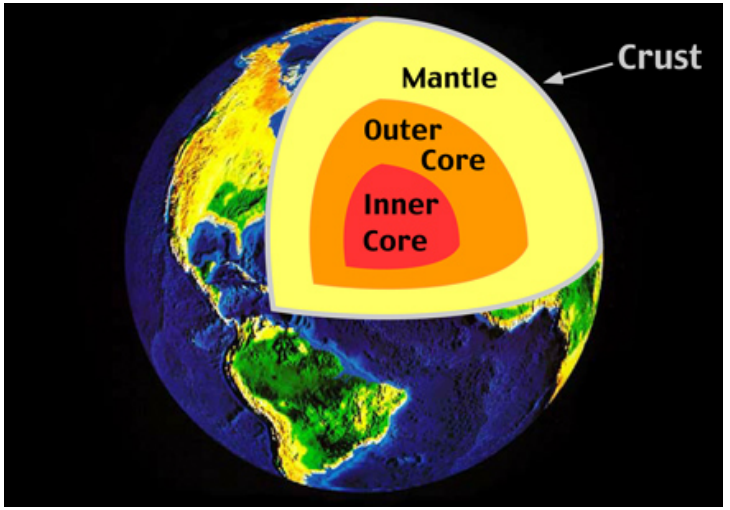
Jane Calvert and Emma Frow at Edinburgh University

Contrasting models for the involvement of social sciences in the "ethical, social and legal issues" (ELSIs) of biosciences

	ELSI model	Post-ELSI model
Focus on	Downstream implications or *consequences* of scientific research	Upstream inherent dimensions or *ramifications* of scientific research
Interaction	Cooperation Handmaiden	Collaboration Partners
Science/Society	Science assumed to be autonomous, neutral	Science/society recognised as entangled

Shift from "Science AND Society" to "Science IN Society"

Intertwined assumptions underlying ELSI model that the post-ELSI model seeks to challenge



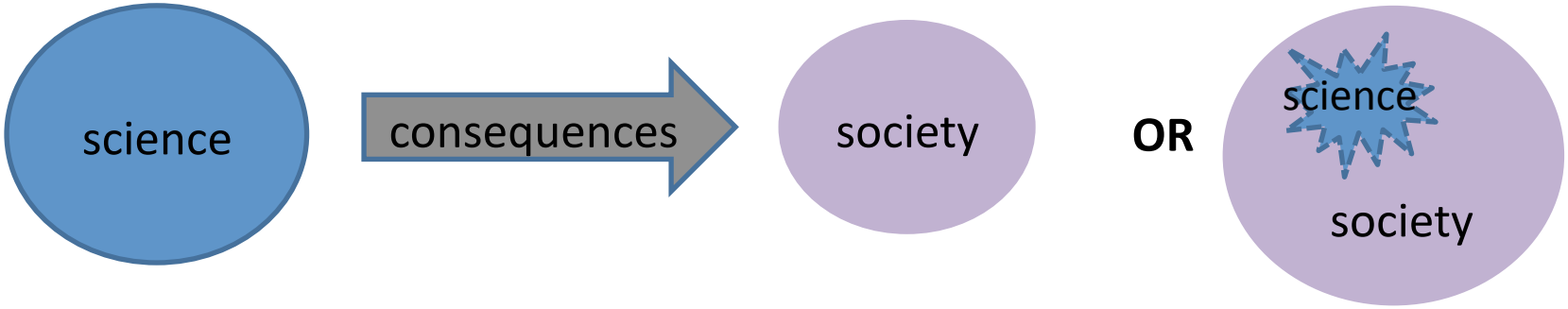
ELSI model of downstream consequences

Deficit model of the public understanding of science

Technocratic/narrow understanding of environmental risk assessment

Linear pipeline model of innovation

Science as autonomous from society



Fears about fears of the public: synbiophobia-phobia

"Another GM?"

"Although synthetic biology can be separated from genetic engineering by its sophistication and its genuine grounding in engineering principles, the fact that it involves the creation and manipulation of living organisms is likely to give rise to many of the same fears that were encountered with genetic engineering."

(RAEng, 2009, p.45)

"Public perceptions and fears of synthetic biology may obstruct research in this field [synthetic biology], in a similar fashion to GM."

(EPSRC, 2009)

Common – but unsubstantiated - explanation for the GM controversy in Europe

- Public misunderstandings about GM technology
- Public fears based on 'biased' perceptions of risk
- Public influenced by irresponsible negative media coverage
- Governments overly influenced by these 'irrational' public reactions

...and this understanding of the past feeds into expectations about the future of synthetic biology

Need to stop blaming the public!

Synbiophobia-phobia is based on pervasive *yet widely discredited* "Deficit Model" of Public Understanding of Science

Unsubstantiated Assumptions:

- Public is receptive and passive
- There is a vacuum in the public's mind
- Fill the vacuum with science

"*public responses are[assumed to be] emotional, dependent, epistemically empty, gullible to manipulation, not questions about 'our' scientific-institutional culture and its assumptions*" (Wynne, 2006)

Wynne, B. (2006). "Public engagement as a means of restoring public trust in science - Hitting the notes, but missing the music?" Community Genetics **9**(3): 211-220.

TEN MYTHS ABOUT THE PUBLIC (Marris et al., 2001)

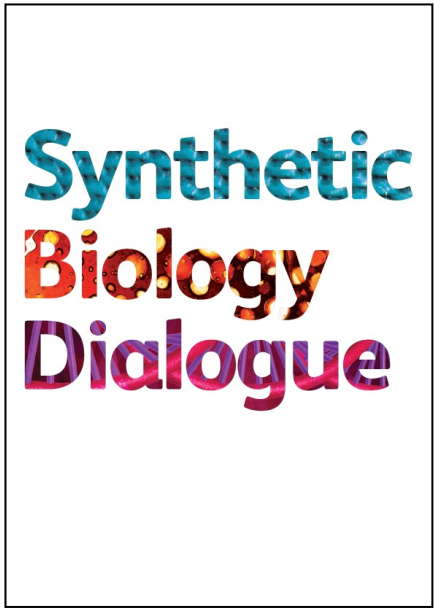
These commonly heard assertions about public perceptions of GMOs were *not* supported by our focus group results

1. **The primordial problem is that lay people are ignorant about scientific facts**
2. **People are either "for" or "against" GMOs**
3. **Consumers accept medical GMOs but refuse GMOs used in food and agriculture**
4. **European consumers are behaving selfishly towards the poor in the Third World**
5. **Consumers want labelling in order to exercise their freedom of choice**
6. **The public thinks - wrongly - that GMOs are "unnatural"**
7. **Since the BSE scandal, citizens no longer trust regulatory institutions**
8. **The public demands "zero risk" - and this is not reasonable**
9. **Public opposition to GMOs is due to "other factors", ethical or political**
10. **The public is a malleable victim of distorting sensationalist media**

BBSRC/EPSRC Synthetic Biology Dialogue 2009-2010

Five central questions emerged for synthetic biology researchers:

- What is the purpose?
- Why do you want to do it?
- What are you going to gain from it?
- What else is it going to do?
- How do you know you are right?



Another commonly heard
– but unsubstantiated –
Assertion that:
"Europeans are anti-GM whereas Americans have accepted GMOs"

In the USA, GMOs do not exist!

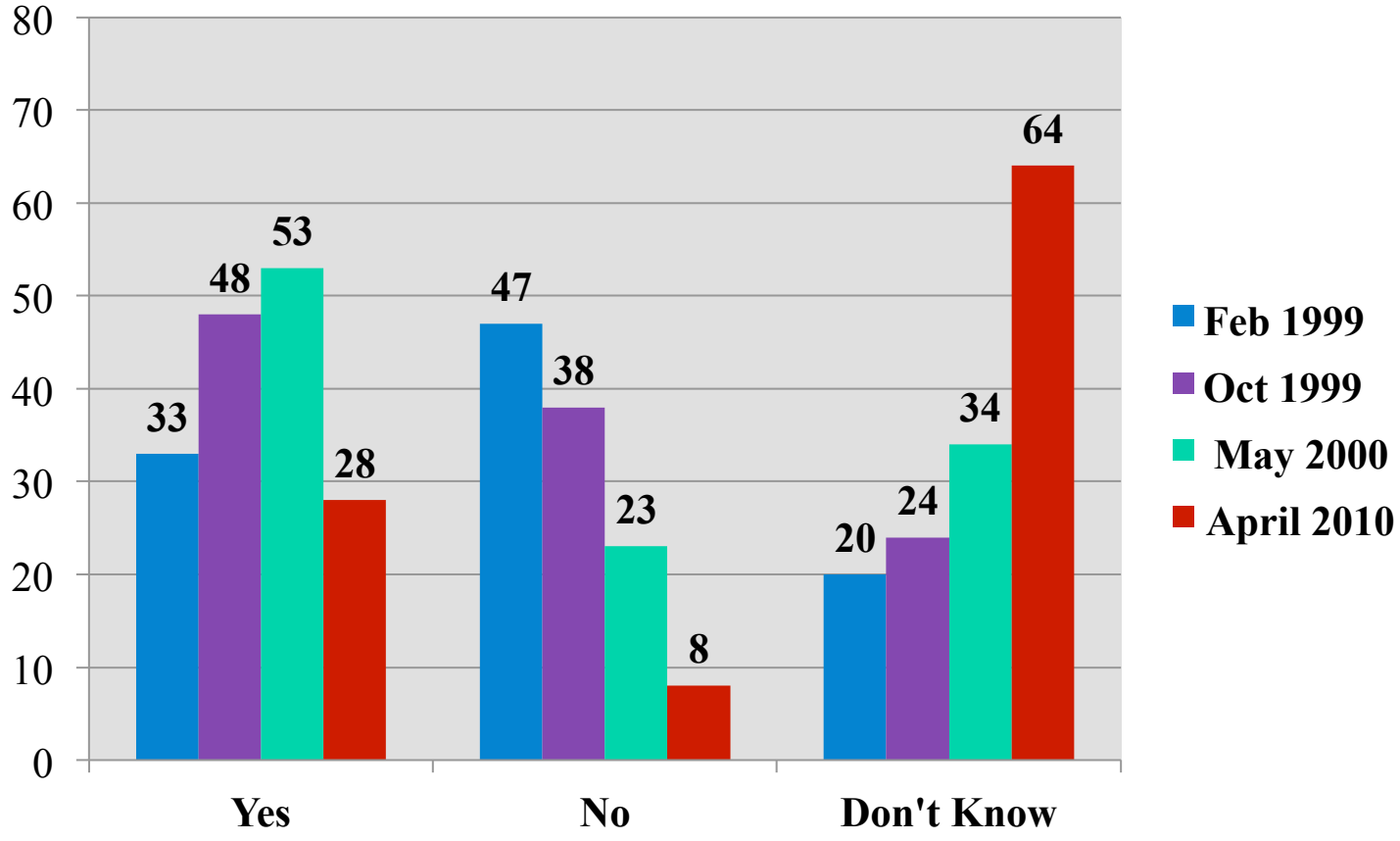
1. **No specific 'process-based' risk regulations for GM product in the USA (but regulated under products-based regulations)**

2. **GM food products in the USA are not labelled**

3. **American consumers do not know that they are consuming GM foods**

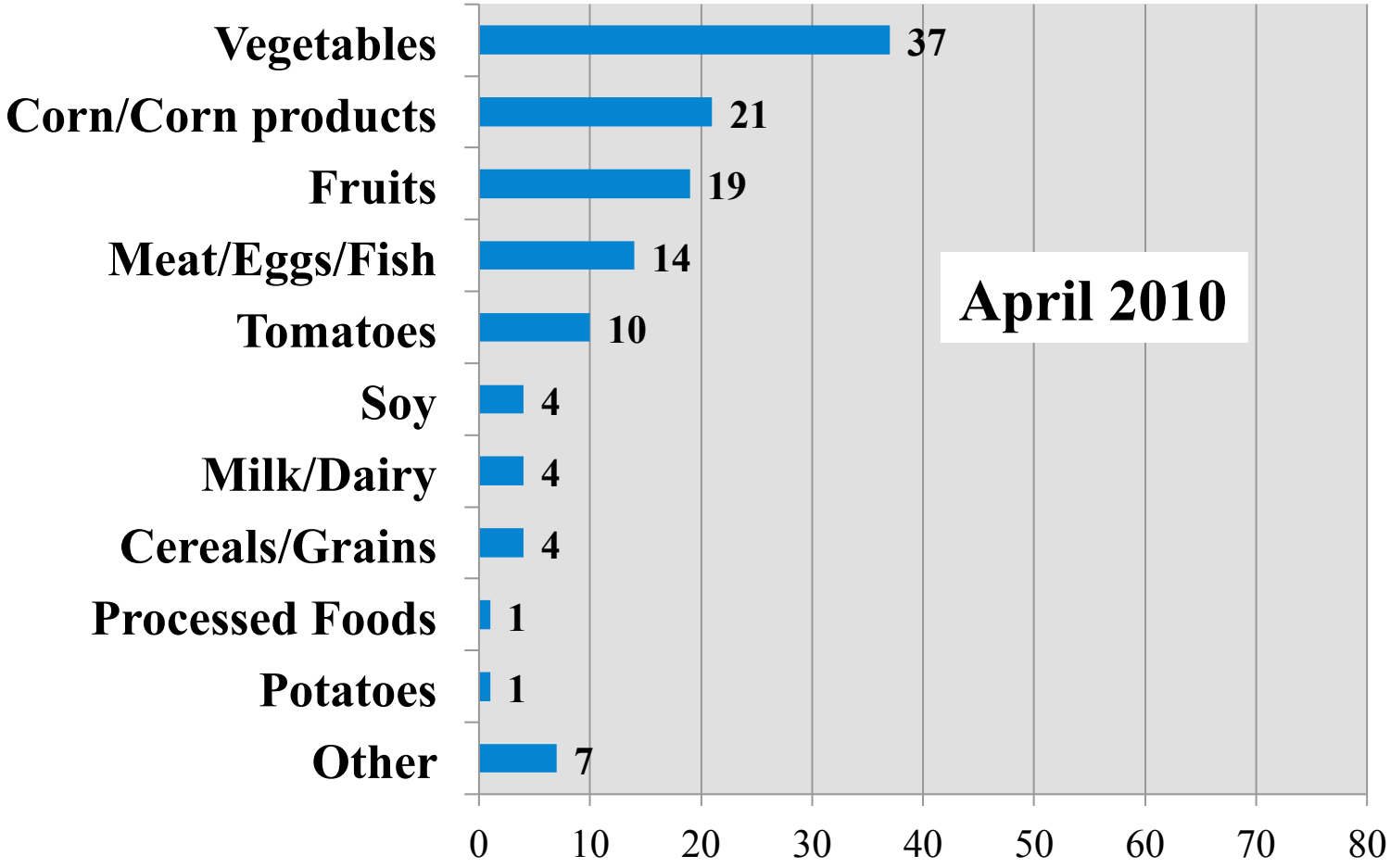
In the USA, GMOs do not exist!

"As far as you know, are there any foods produced through biotechnology in the supermarket now?" (Source: IFIC)



International Food Information Council Foundation http://www.foodinsight.org

(Among those who said "yes")
"Which biotech foods are available in the supermarket now?



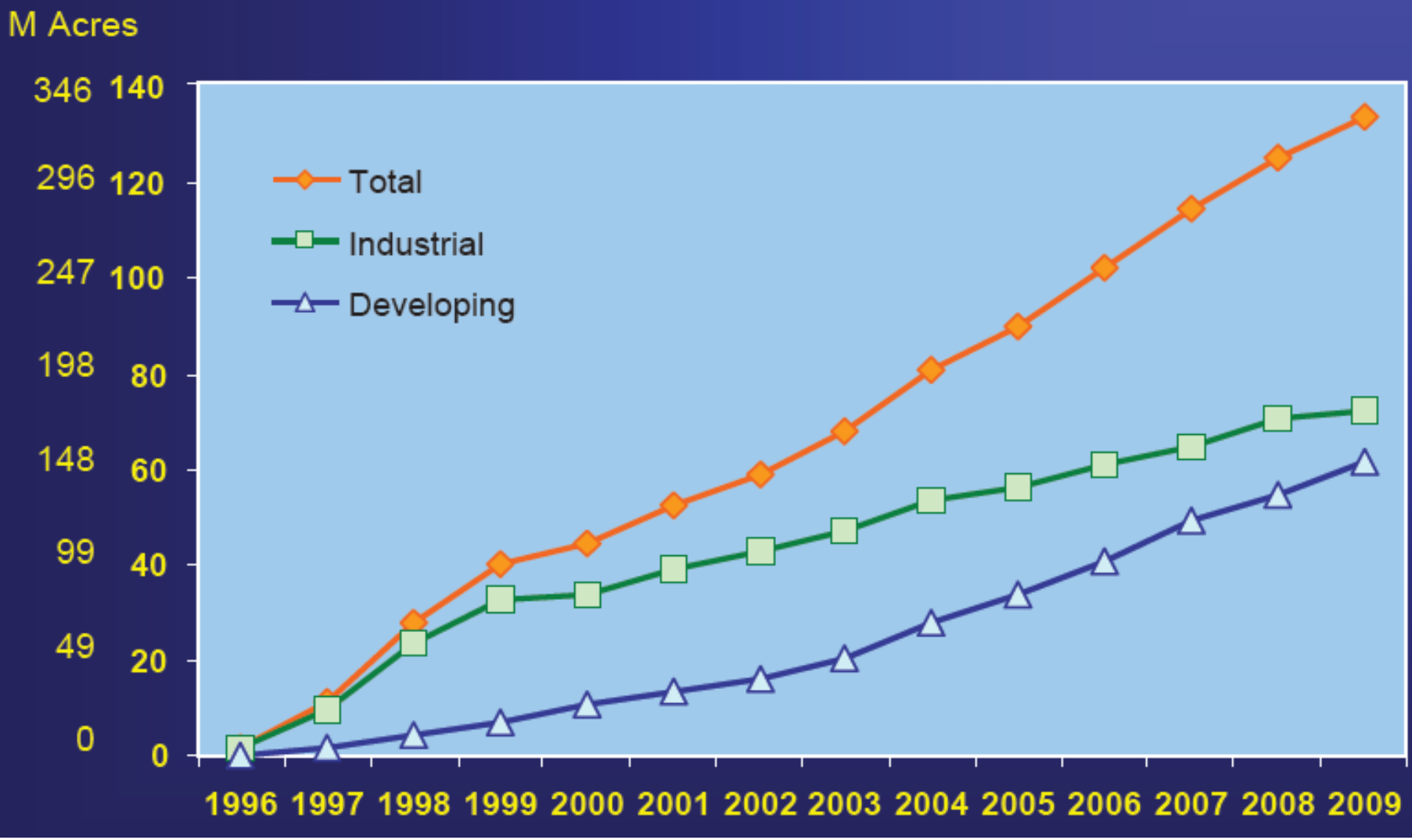
International Food Information Council Foundation http://www.foodinsight.org

- **The difference in GM policy and use in USA and Europe cannot be explained by public opinion**

- **Data and assumptions about 'the public' are part of the controversy itself**

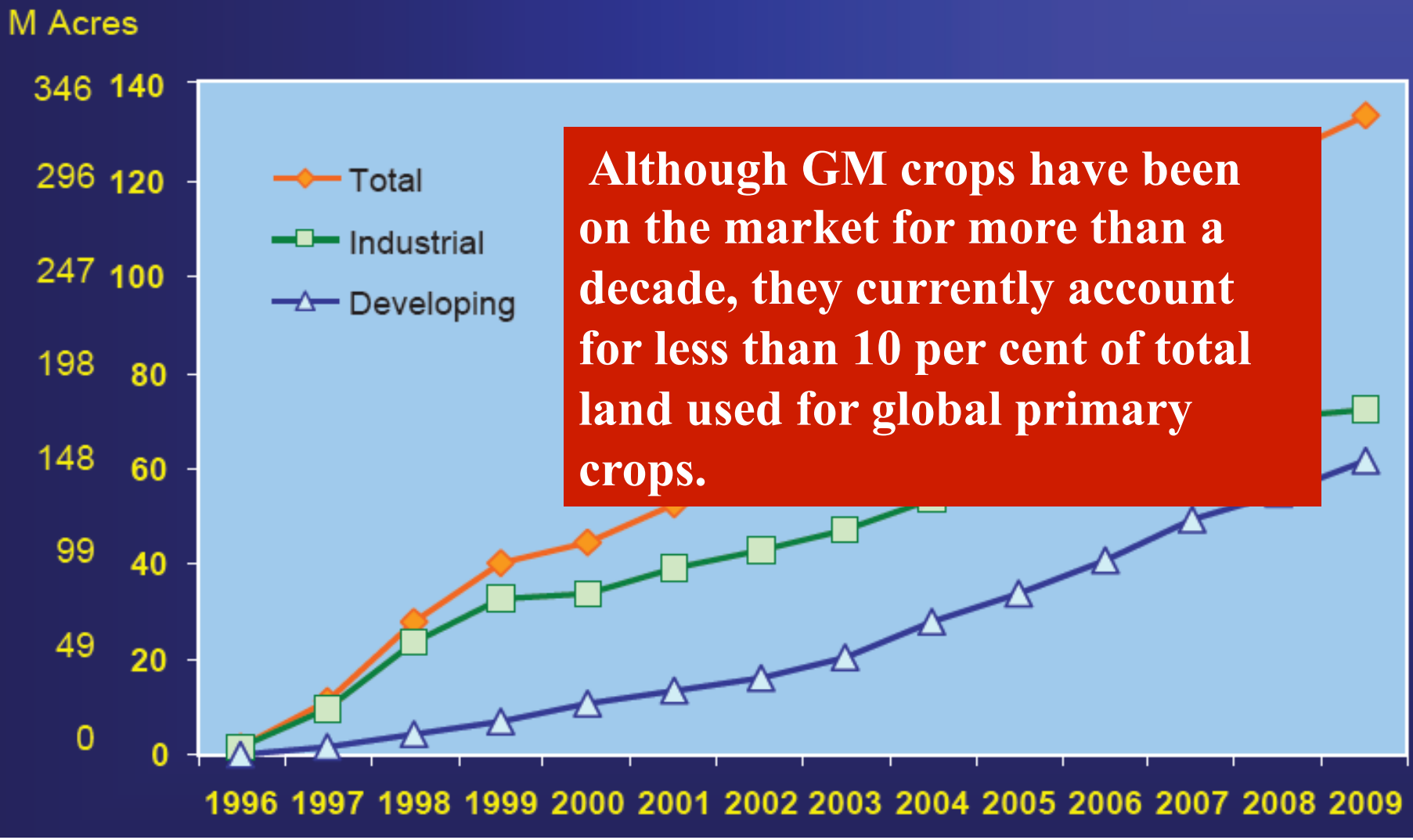
- **Data and assumptions about (increase of) GM crop surfaces are part of the controversy itself**

Global Area of Biotech Crops, 1996 to 2009: Industrial and Developing Countries (M Has, M Acres)



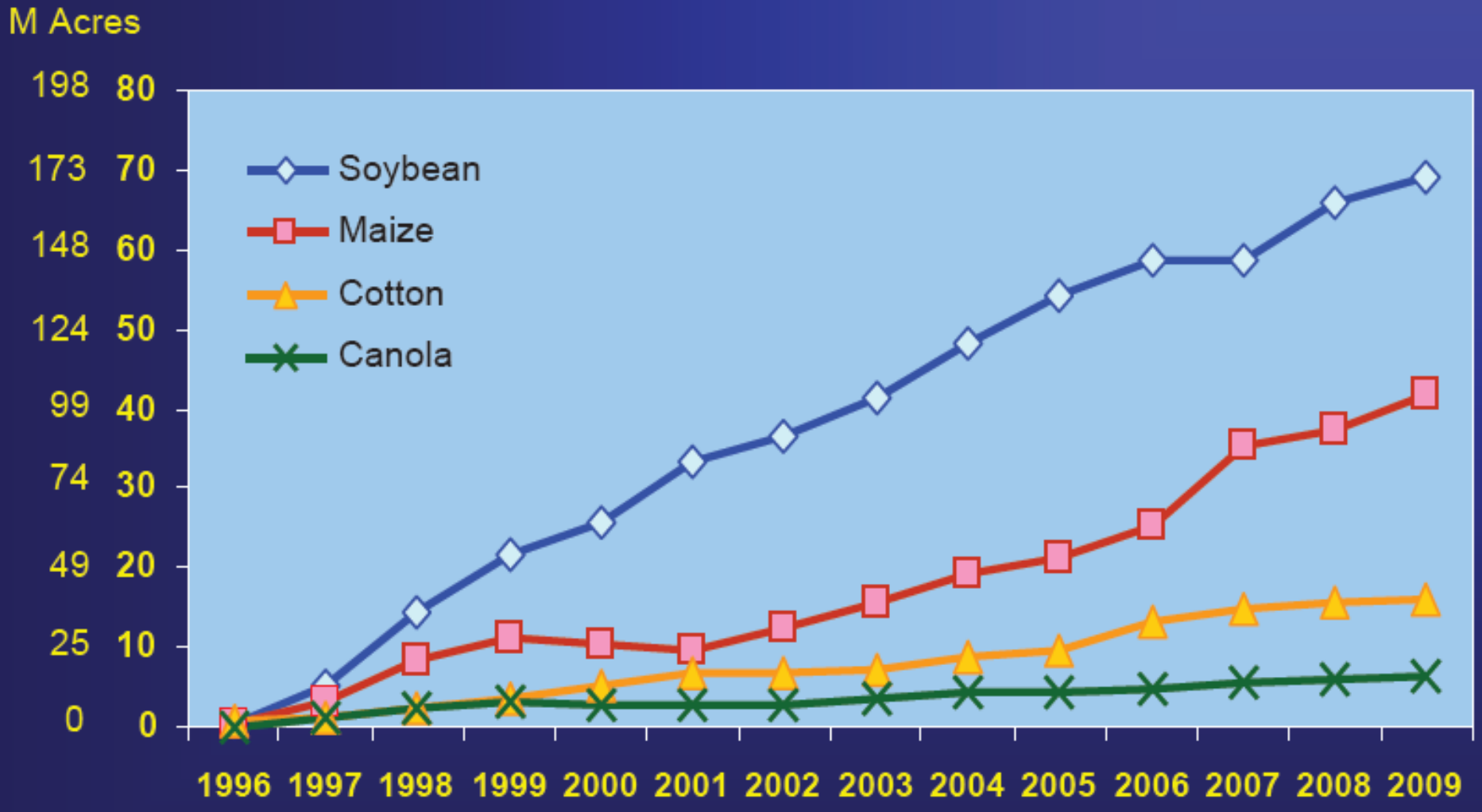
Global Area of Biotech Crops, 1996 to 2009: Industrial and Developing Countries (M Has, M Acres)

ISAAA



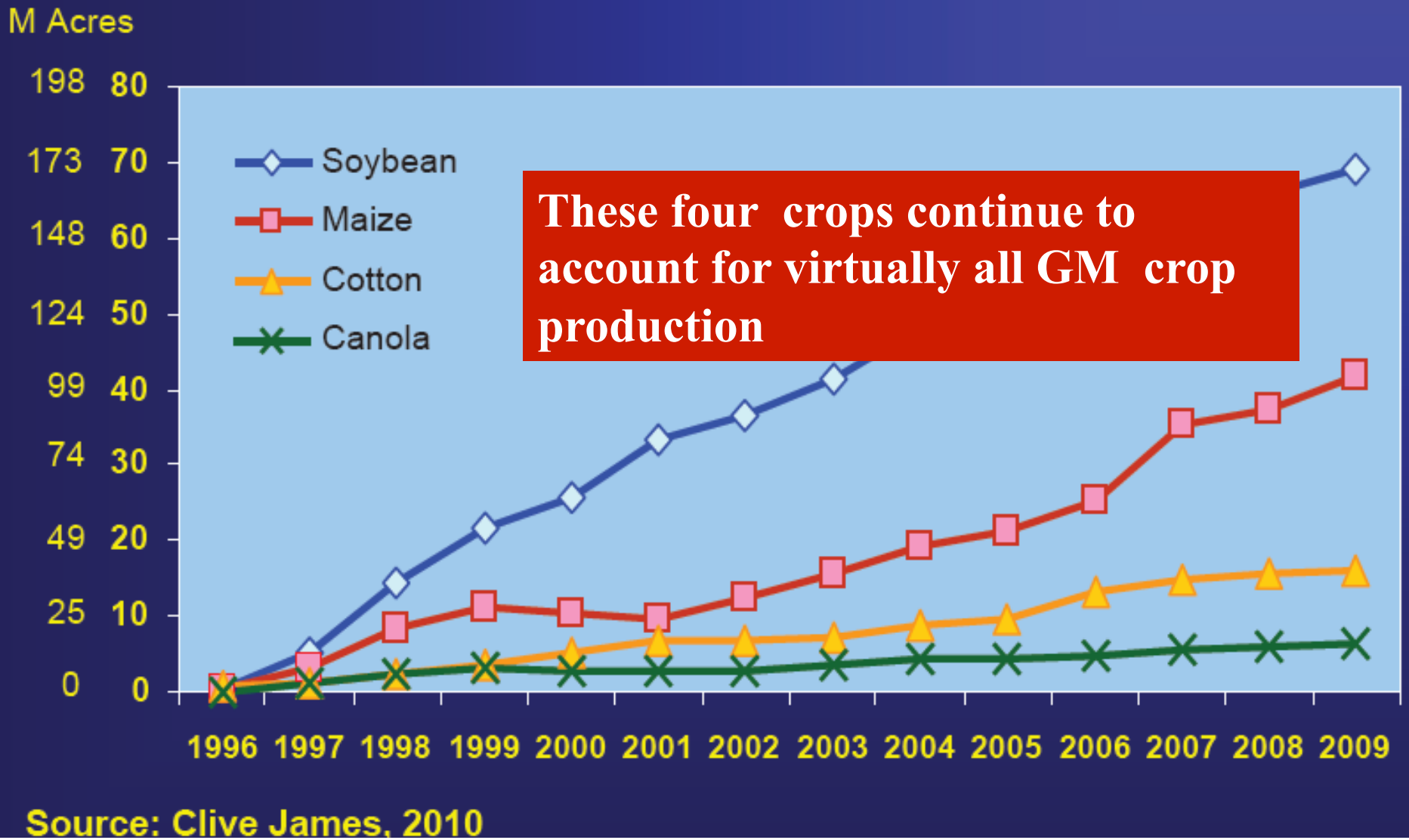
Although GM crops have been on the market for more than a decade, they currently account for less than 10 per cent of total land used for global primary crops.

Global Area of Biotech Crops, 1996 to 2009: By Crop (Million Hectares, Million Acres)



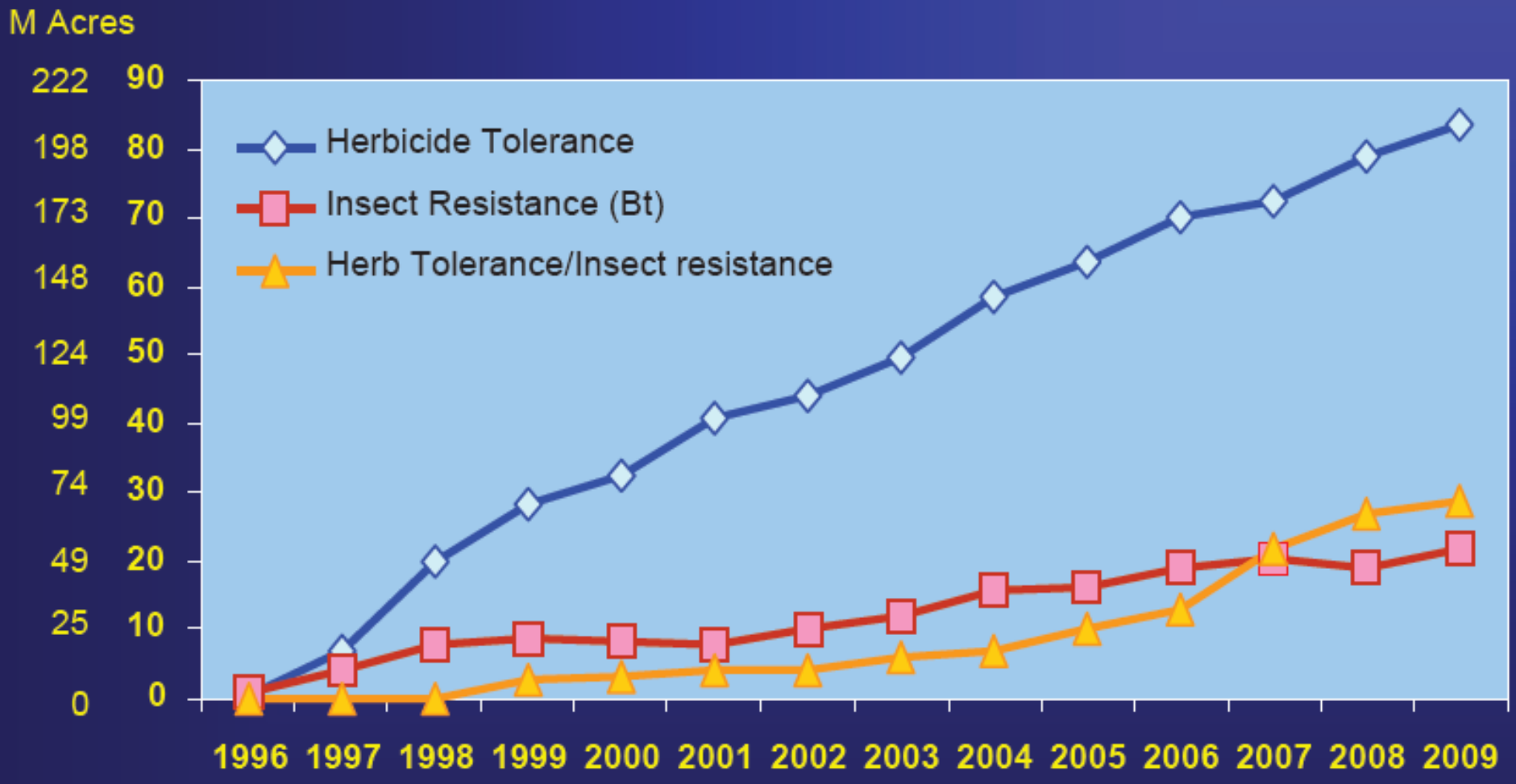
Source: Clive James, 2010

Global Area of Biotech Crops, 1996 to 2009: By Crop (Million Hectares, Million Acres)



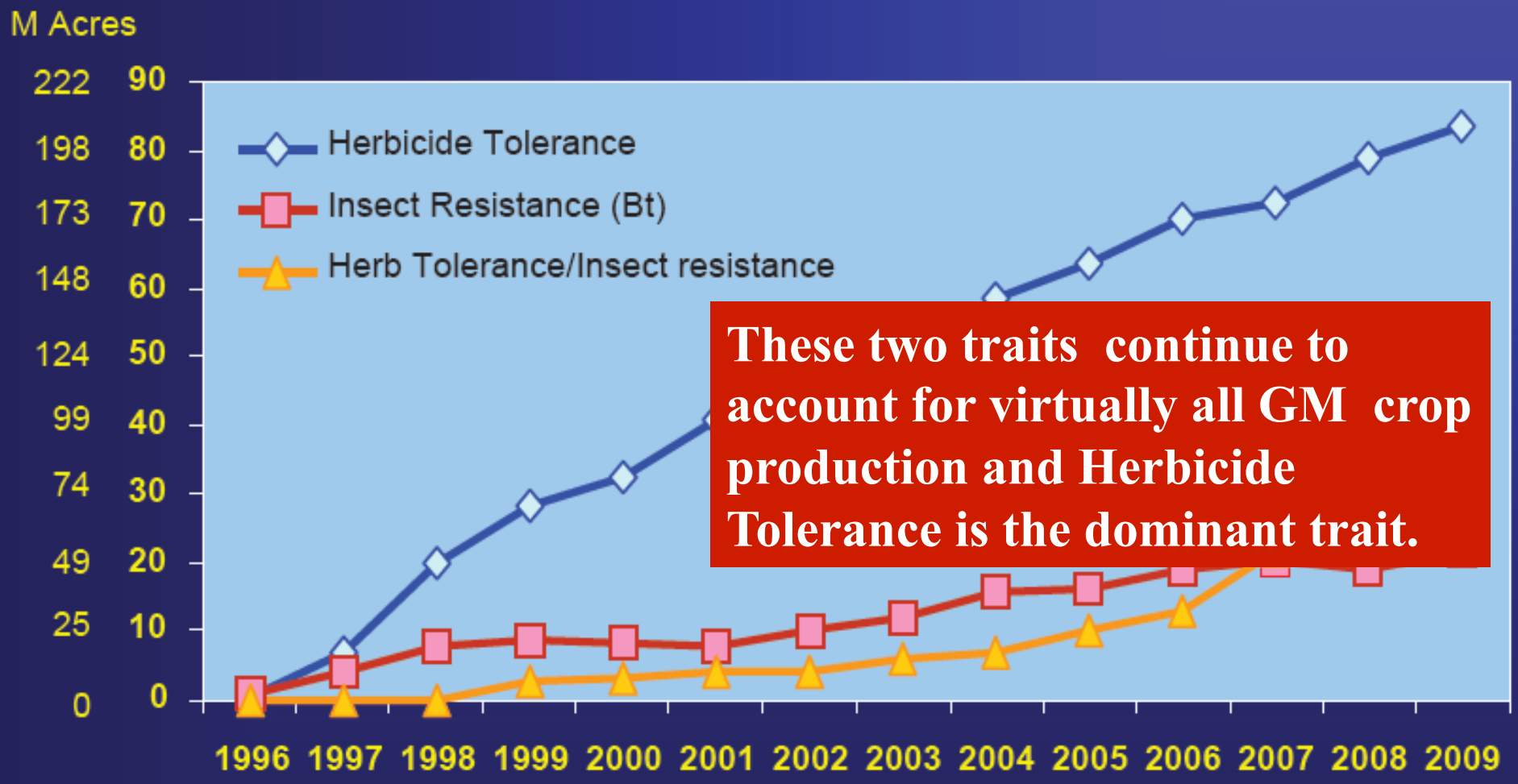
Source: Clive James, 2010

Global Area of Biotech Crops, 1996 to 2009: By Trait (Million Hectares, Million Acres)



Source: Clive James, 2010

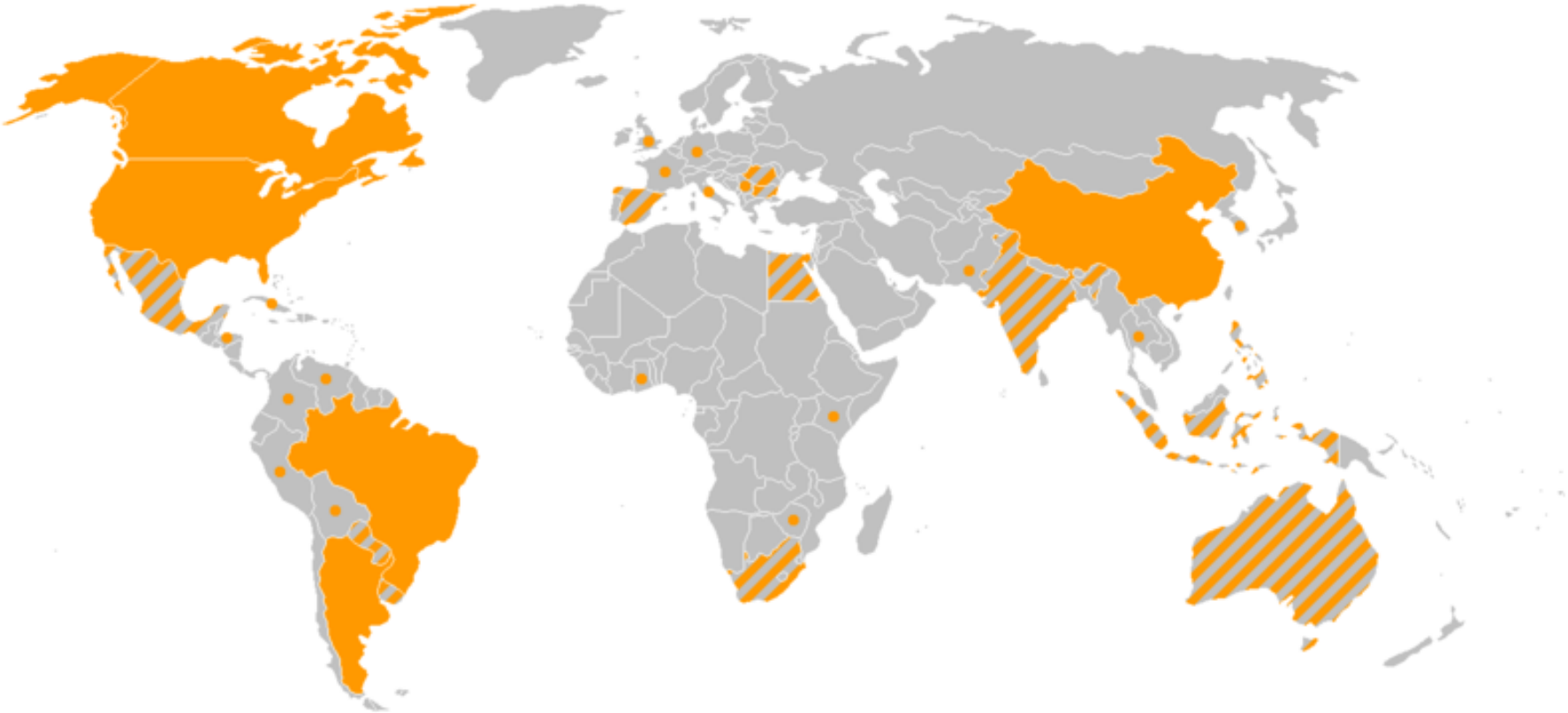
Global Area of Biotech Crops, 1996 to 2009: By Trait (Million Hectares, Million Acres)



These two traits continue to account for virtually all GM crop production and Herbicide Tolerance is the dominant trait.

Source: Clive James, 2010

Commercial GM crops around the world in 2005



Solid orange: The five countries producing more than 95% of commercialized GM crops (USA, Canada, Brazil, Argentina, China)

Stripy orange: Other country producing commercialized GM crops

Orange dot: Only experimental crops

In 2009: 3 countries (USA, Brazil and Argentina) account for 81% of surfaces (ISAAA, 2010)

Can Plant Synthetic Biology do better?

- Stop blaming the public for their supposedly irrational 'lack of acceptance'.

- Develop food crops that can demonstrate that they really are more environmentally sustainable, and/or increase food security in developing countries (without need for additional infrasctructure and water/other inputs?).

- Develop non food plants that fulfil societal needs in more sustainable ways.

- Don't just assume benefits: engage with a wide range of experts and stakeholders in order to better understand real-world problems and how your research might contribute.

Thank-you for your attention
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