Responsible Innovation:

From Science in Society to Science for Society, with Society

Phil Macnaghten

Knowledge, Technology and Innovation Group

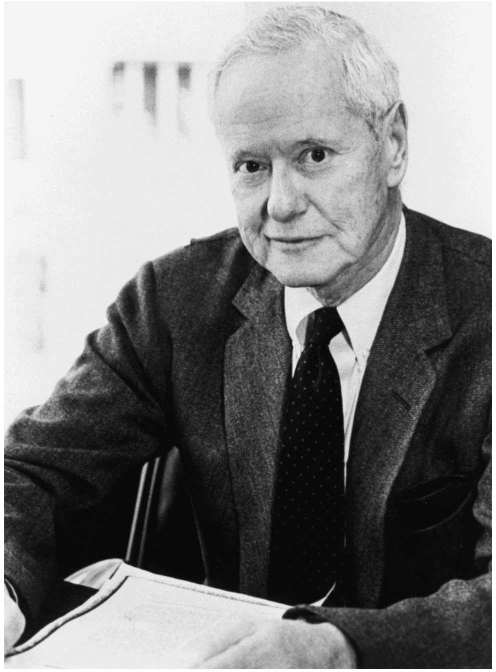
WAGENINGEN UR

For quality of life

Responsibility 1.0: Pure Science

To produce reliable knowledge accomplished by enforcing institutional norms (CUDOS)

- Communalism
  - all scientists should have common ownership
- Universalism
  - scientific validity is independent of status
- Disinterestedness
  - scientific institutions act for the benefit of a common scientific enterprise
- Organised Skepticism
  - scientific claims should be exposed to critical scrutiny



Robert Merton, 1942

Responsibility 1.0: Linear model (1945 –)

"Science: The Endless Frontier", 1945

Basic science → Applied science → Technological development → New products and services → Prosperity!

1. Basic scientists **do not** and **should not** consider applications
2. But applications will emerge from basic science
3. And the nations that support the basic science will gain economic rewards
4. (The Republic of Science, Polanyi 1962)

Vannevar Bush

Responsibility 2.0: Science in Society (2000 –)

- Disasters and crises of confidence (1980s/ 1990s)
  - Bhopal, Three Mile Island, Chernobyl, Challenger, BSE, GM crops, 9/11, financial markets, research misconduct,
- Pressure from governments (and society)
  - publicly funded science to deliver clearer economic and societal benefits
  - *goal-oriented*, intrinsically interdisciplinary science
  - agenda set by a societal and economic context rather than by an academic discipline
- Science contextualised by societal challenges
- Horizon 2020
  - Health, demographic change and wellbeing
  - Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy
  - Secure, clean and efficient energy
  - Smart, green and integrated transport
  - Climate action, environment, resource efficiency and raw materials
  - Europe in a changing world - inclusive, innovative and reflective societies
  - Secure societies - protecting freedom and security of Europe and its citizens

The Lund Declaration 2015

EUROPE MUST SPEED UP SOLUTIONS TO TACKLE GRAND CHALLENGES THROUGH ALIGNMENT, RESEARCH, GLOBAL COOPERATION AND ACHIEVING IMPACT

The Lund Declaration 2009 called upon Member States and European Institutions to focus research on the grand challenges of our times by moving beyond rigid thematic approaches and aligning European and national strategies and instruments. During the last six years European institutions, member states and associated countries have taken important steps to align and coordinate resources and shift the focus towards society's major challenges.

Today Europe still faces a wide range of major challenges and business as usual is not an option. The Lund Declaration 2015 therefore emphasises the urgency of increased efforts in alignment at national and European level and that investments in research and innovation better and more rapidly be exploited to the benefit of society.

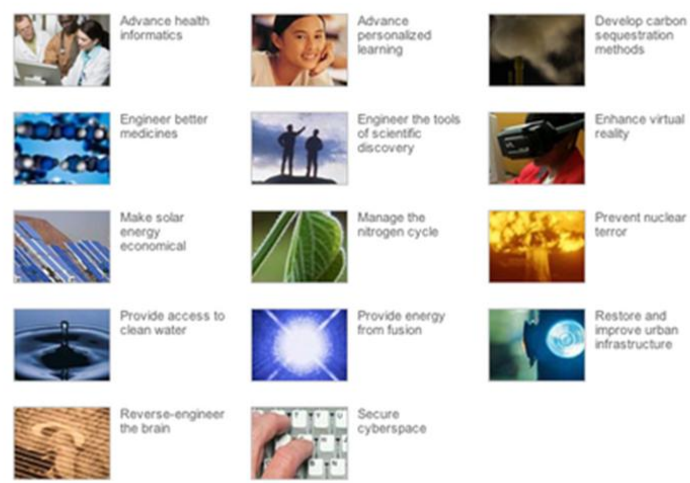
It identifies four priority areas, each with defined priority actions, and calls on all stakeholders to take these priorities into account in their field of responsibility.

- Europe needs clear political commitment to step-up efforts to align strategies, instruments, resources and actors at national and European level in order to address the grand societal challenges.
- This commitment needs to be underpinned by an excellent science base, world-class research infrastructures and a new generation of researchers with the right set of skills, notably creativity, entrepreneurship and innovation.
- Europe needs to connect with partners around the world, in advanced, emerging and developing countries to address the grand societal challenges in partnership and to attract the world's best researchers and innovators and private sector investment.
- Greater impacts on the challenges have to be achieved through involvement of the public sector and industry in knowledge creation, with a stronger focus on open innovation and the role of end-users.

GCRF

Global Challenges Research Fund

Grand Challenges of Engineering



Computing/ communication

Energy

Heathcare

Safe drinking water

Security

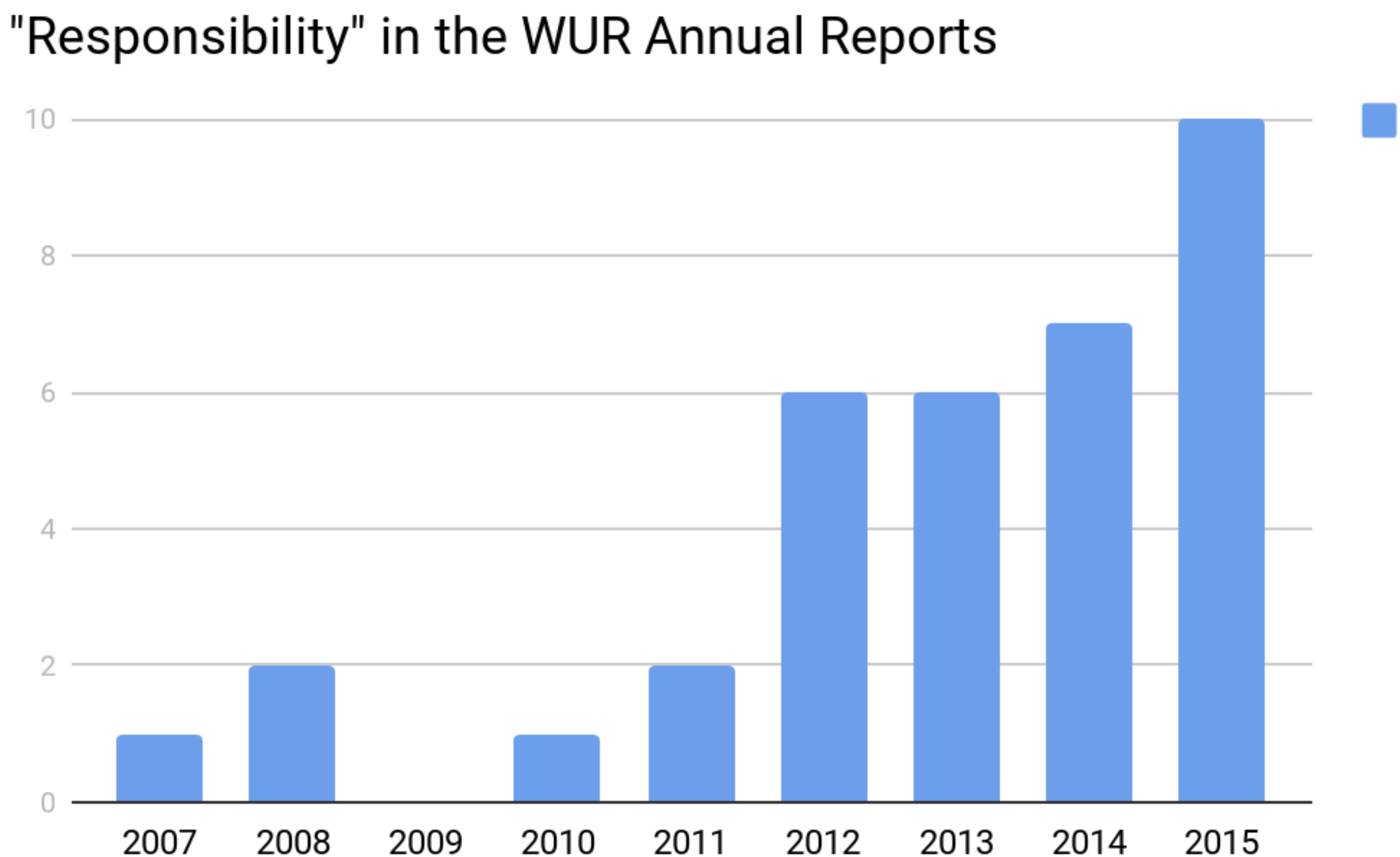
Global warming

Responsibility 2.0: Science for Societal impact

"**Animal production**, being an essential part of the bio-economy, has the **responsibility** to provide the **growing world population** with sufficient, nutritious, safe, healthy and climate smart food (animal proteins). This is a **huge challenge**. At a global level, the consumption of animal proteins (milk, meat, eggs and seafood) is expected to increase substantially over the next 30 years while in Europe the consumption of animal proteins is expected to remain stable."
(Johan van Arendonk 2017)

"**Our world is changing**. The population is growing fast and prosperity is increasing in many regions. Around the world, land use for food production is reaching its limits. The climate is visibly changing while fossil fuels are becoming ever scarcer. Meanwhile, people are attaching more importance to healthy, safe and sufficient food. It is this changing world that is the real **specialisation of WUR** – …. In essence we not only develop knowledge but also help to apply it."
(Corporate brochure WUR 2017)

Grand challenges → **Challenge programmes** → **Interdisciplinary research** → **Innovative solutions** → **Sustainability!**


"Responsibility" in the WUR Annual Reports
10
8
6
4
2
0
2007
2008
2009
2010
2011
2012
2013
2014
2015

Responsibility 3.0: Science for society, with society

Outstanding questions for challenge-led science

- Does it restore public trust?
- Does it command legitimacy?
- Does it focus on the right challenges?
- Does the science we use to solve problems create new problems?

Responsibility 3.0: Responsible innovation (2010 –)

“taking care of the future through collective stewardship of science and innovation in the present”

(Stilgoe, Owen and Macnaghten 2013)

Responsibility 3.0: Responsive science

Responsible innovation needs to respond to kinds of questions that publics typically ask of scientists and innovators, or would like to see scientists ask of themselves

a. Purposes
b. Trust
c. Inclusion
d. Speed and direction
e. Ethics and trade-offs

Responsibility 3.0: Lines of questioning on responsibility

Product questions	*Process questions*	*Purpose questions*
What are the likely risks and benefits ?	How should research and innovation take place?	Why should this research be undertaken?
How will the risks and benefits be distributed ?	How should standards be drawn up and applied?	Why are researchers doing it?
What other impacts can we anticipate?	How should risks and benefits be defined and measured?	Are these motivations transparent and in the public interest?
How might these change in the future?	Who is in control?	Who will benefit?
What don't we know about?	Who is taking part?	What are they going to gain?
What might we never know about?	Who will take responsibility if things go wrong?	What are the alternatives?
	How do we know we are right?	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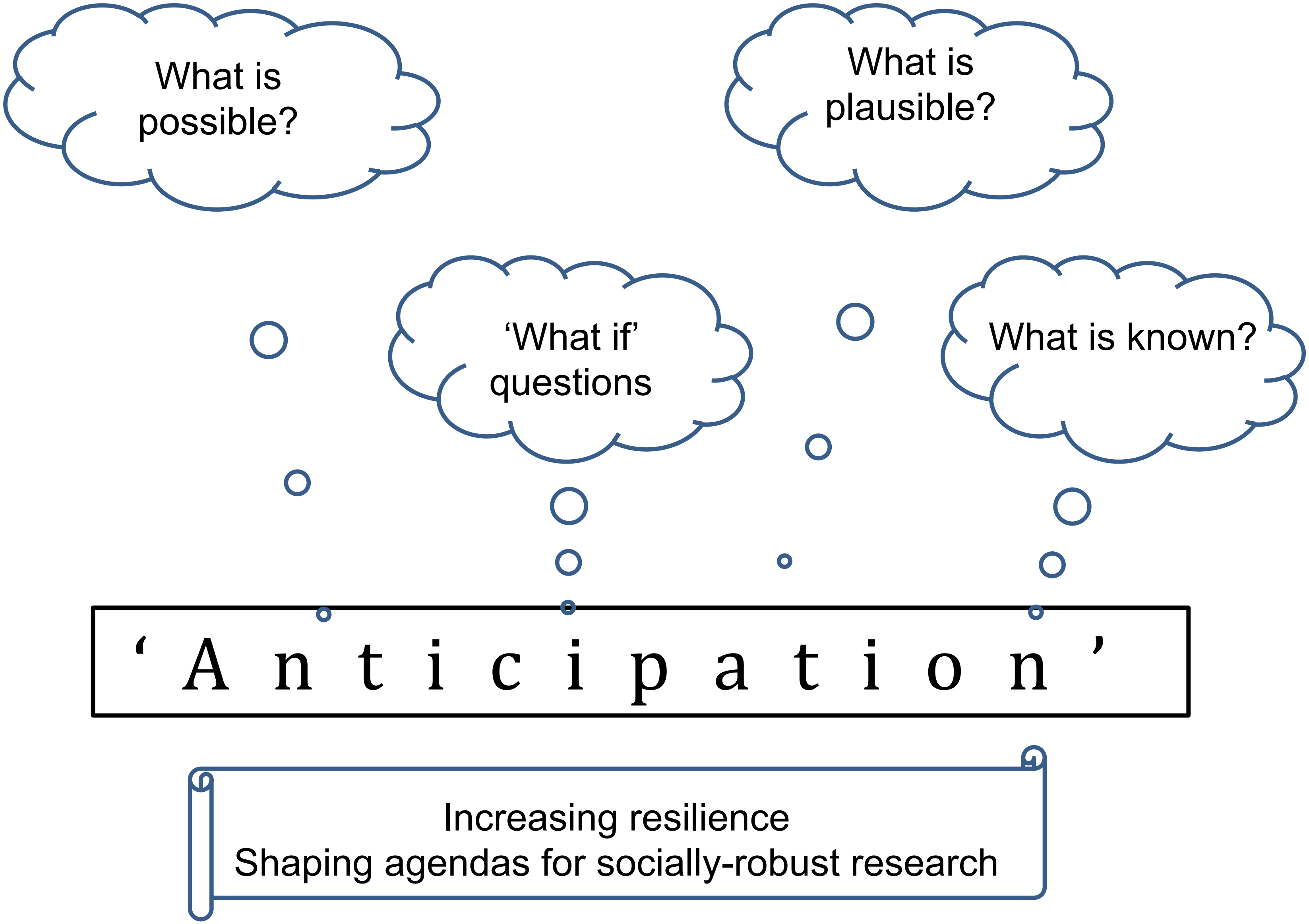
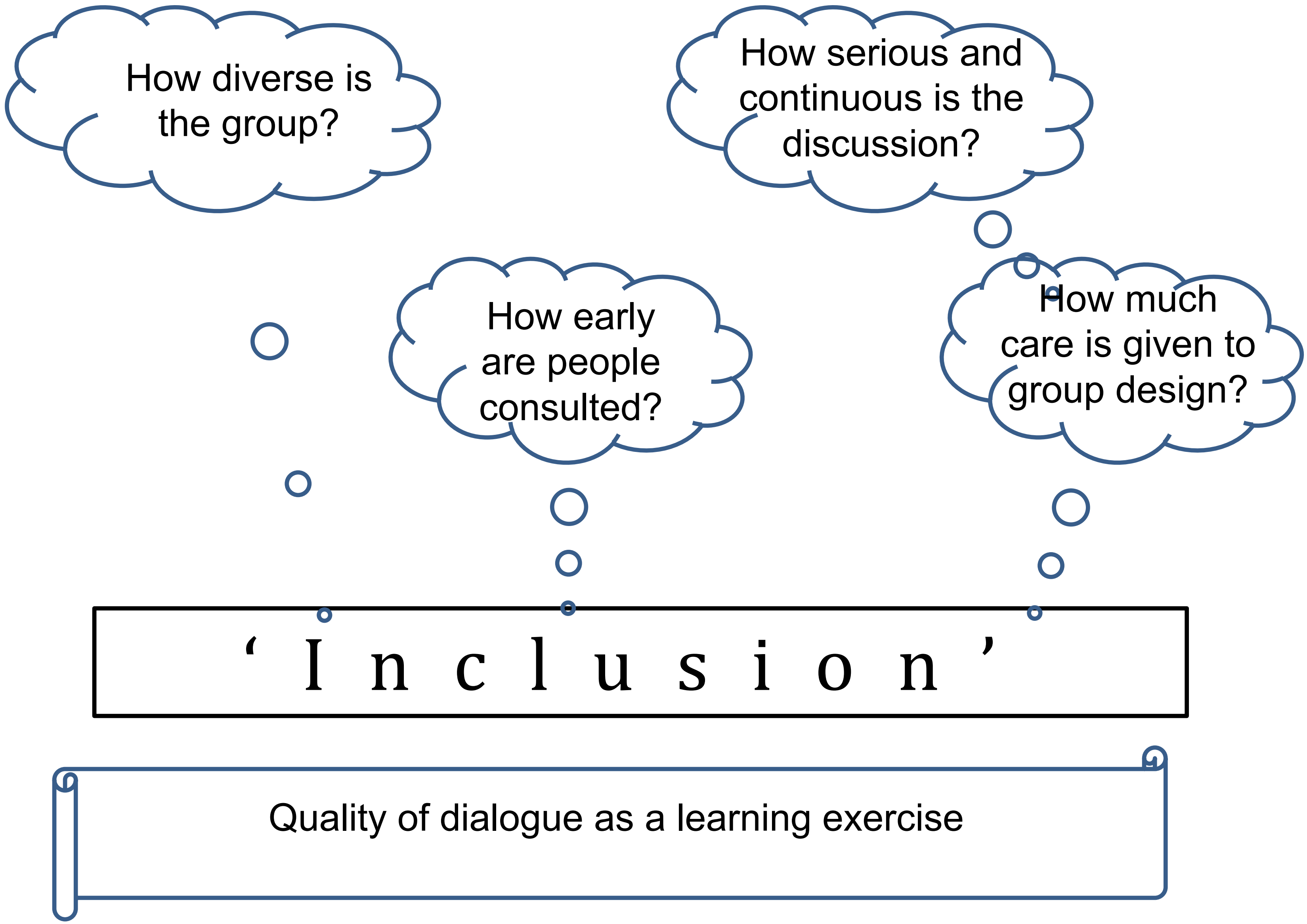
Anticipation!

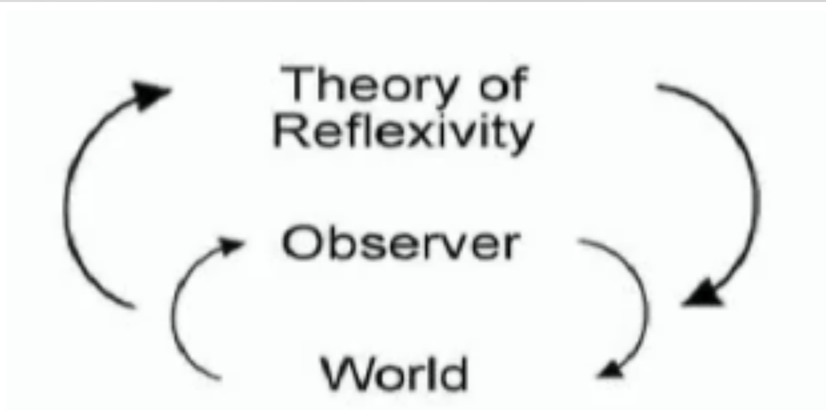

What is possible?
What is plausible?
'What if' questions
What is known?
'Anticipation'
Increasing resilience
Shaping agendas for socially-robust research

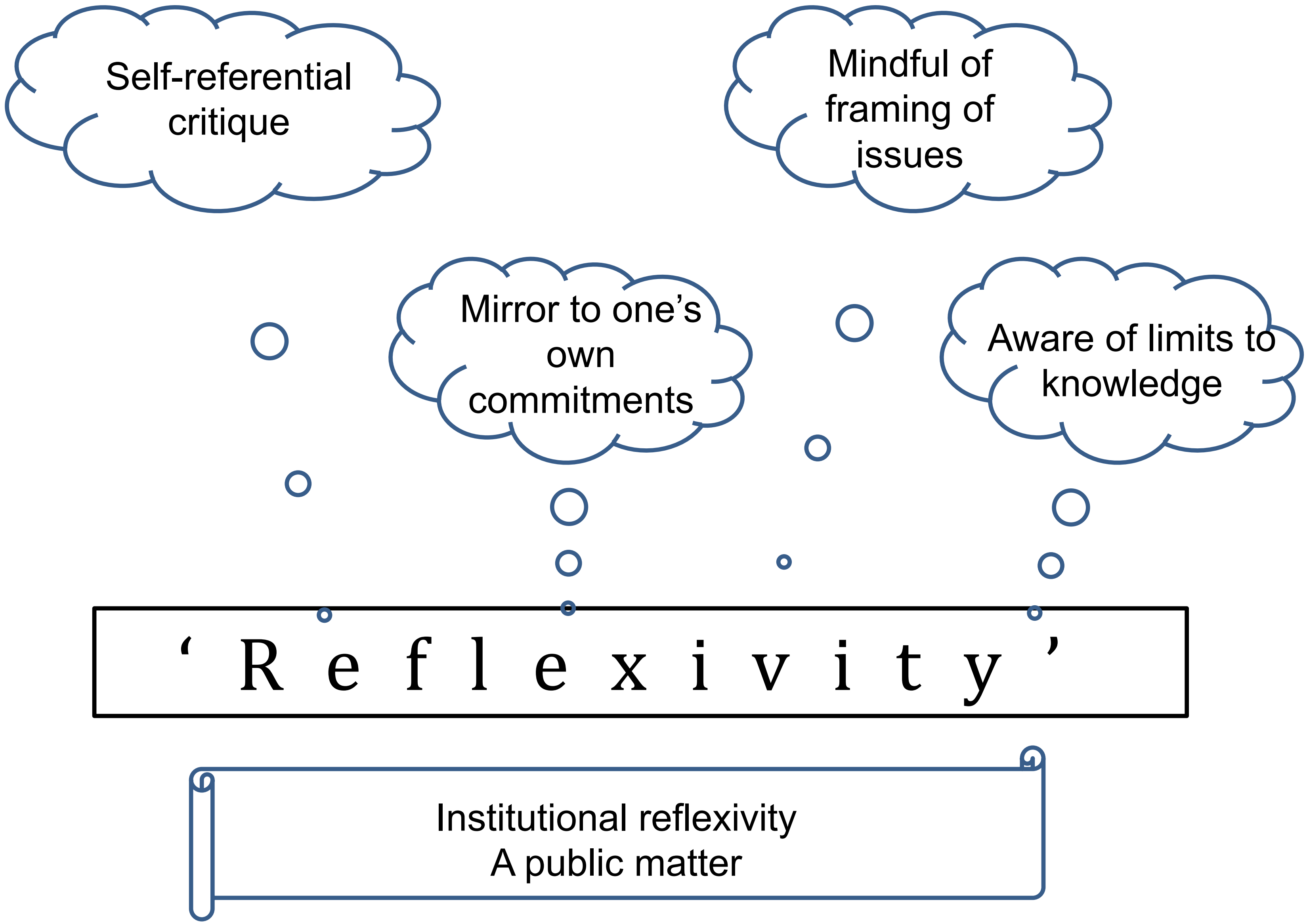
Dimension	Indicative techniques and approaches	Factors affecting implementation
Anticipation	Foresight Technology assessment Horizon scanning Scenarios Vision assessment Socio-literary techniques	Engaging with existing imaginaries Participation rather than prediction Plausibility Investment in scenario-building Scientific autonomy and reluctance to anticipate


inclusion


How diverse is the group?
How serious and continuous is the discussion?
How early are people consulted?
How much care is given to group design?
'Inclusion'
Quality of dialogue as a learning exercise

Dimension	Indicative techniques and approaches	Factors affecting implementation
Inclusion	Consensus conferences Citizens' juries and panels Focus groups Science shops Deliberative mapping Deliberative polling Lay membership of expert bodies User-centred design Open innovation	Questionable legitimacy of deliberative exercises Need for clarity about, purposes of and motivation for dialogue Deliberation on framing assumptions Ability to consider power imbalances Ability to interrogate the social and ethical stakes associated with new science and technology Quality of dialogue as a learning exercise

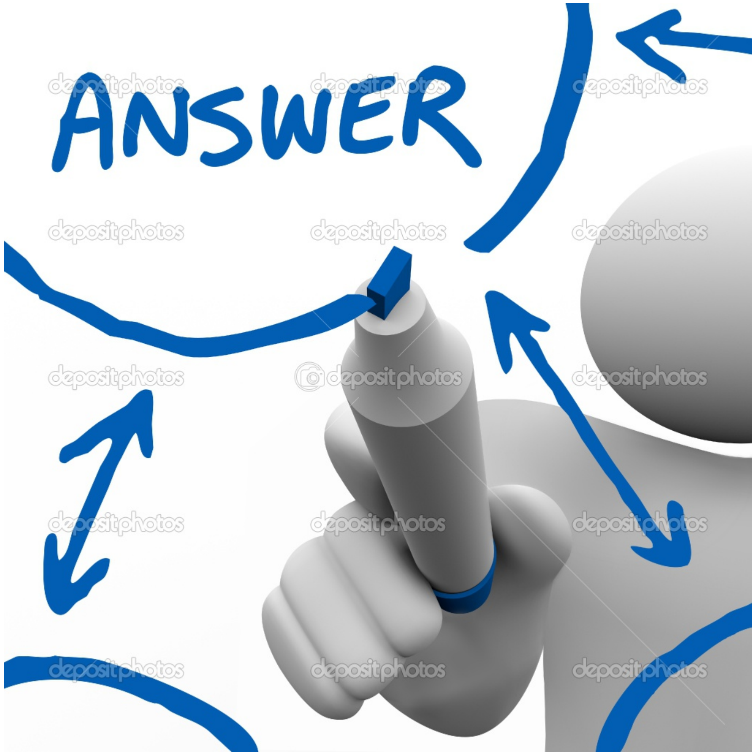

Theory of
Reflexivity
Observer
World

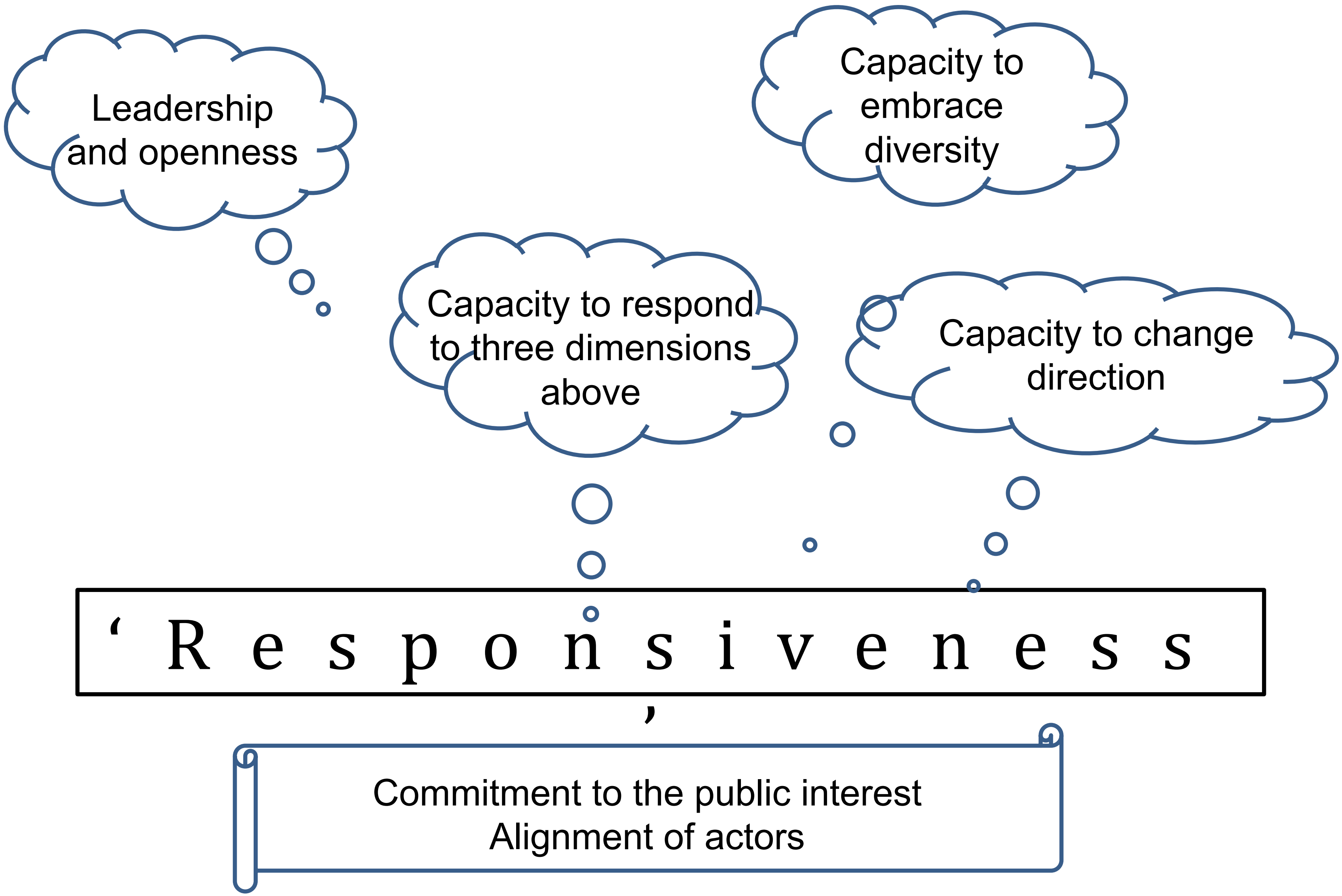

Self-referential critique
Mindful of framing of issues
Mirror to one's own commitments
Aware of limits to knowledge
'Reflexivity'
Institutional reflexivity
A public matter

Dimension	Indicative techniques and approaches	Factors affecting implementation
Reflexivity	Multidisciplinary collaboration and training Embedded social scientists and ethicists in laboratories Ethical technology assessment Codes of conduct Moratoriums	Rethinking moral division of labour Enlarging or redefining role responsibilities Reflexive capacity among scientists and within institutions Connections made between research practice and governance

RESPONSIVENESS

react




Leadership and openness
Capacity to embrace diversity
Capacity to respond to three dimensions above
Capacity to change direction
'Responsiveness'
Commitment to the public interest
Alignment of actors

Dimension	Indicative techniques and approaches	Factors affecting implementation
Responsiveness	Constitution of grand challenges and thematic research programmes	Strategic policies and technology 'roadmaps'
	Regulation	Science-policy culture
	Standards	Institutional structures
	Open access and other mechanisms of transparency	Institutional cultures
		Institutional leadership
	Niche management	Openness and transparency
	Value-sensitive design	Intellectual property regimes
	Provision of information	Technological standards
	Labelling	
	Moratoriums	
	Stage-gates	
	Alternative intellectual property regimes	
	New institutional structures and norms	

Case 1: GM crops and foods (1996/1997)

UK Sources of Public Unease to GM foods

1. Who is driving these developments and why?
   - Scepticism over claimed social benefits of GM
   - Implied future model of agriculture
2. Boundary issues
   - Escalating 'tampering' with nature (likelihood of retribution)
   - Transgression of moral boundaries - the 'integrity' of life
   - Qualitatively different from conventional selective breeding re. speed and precision of intervention
3. Mistrust over 'scientific' reassurances
   - BSE as heuristic - dispelling 'innocence'
4. Organised 'irresponsibility'
   - Who will be responsible if and when things go wrong
   - Regulatory frameworks seen as compromised by prior commitment to expansion of biotechnology overall
5. Lack of overall sense of ownership of the technology
   - Feelings of inevitability and fatalism; technology seen as imposed, pervasive

Case 2: Nanotechnology (2004 –2009)

Towards an ‘upstream’ methodology

Case 3. The Stratospheric **P**article **I**njection for **C**limate **E**ngineering (SPICE) project

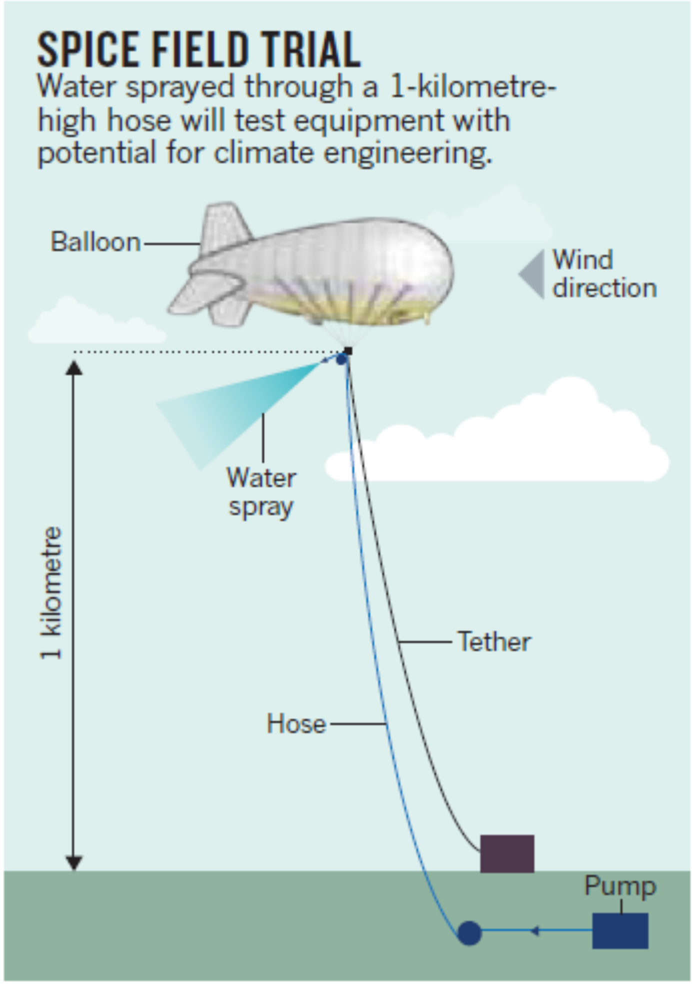


Figure Macnaghten and Owen, 2011

The Stakes:

A balloon 1 km high spraying water over Cambridgeshire

or

UK's 1st field trial of climate-engineering technology

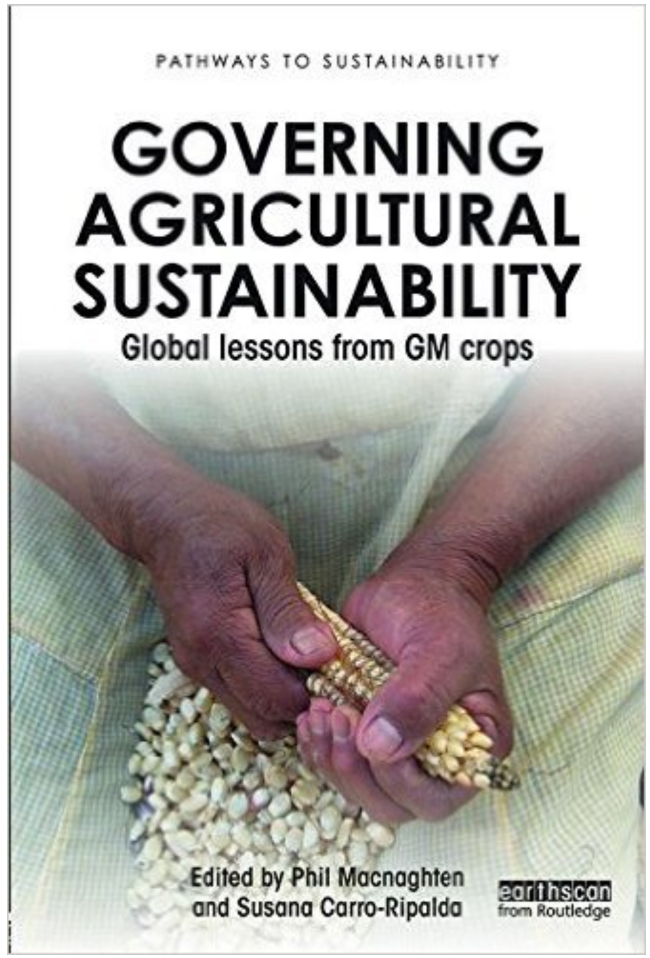
Case 4

Global lessons from GM crops

Three global rising powers


- GM Maize in Mexico
- GM Soya in Brazil
- GM Cotton in India





PATHWAYS TO SUSTAINABILITY
GOVERNING AGRICULTURAL SUSTAINABILITY
Global lessons from GM crops
Edited by Phil Macnaghten and Susana Carro-Ripalda
earthscan from Routledge

FRAMEWORK FOR RESPONSIBLE INNOVATION

EPSRC is committed to develop and promote Responsible Innovation. This site reaffirms our own commitment and sets out our expectations for the researchers we fund and their research organisations.

INTRODUCTION

Responsible Innovation is a process that seeks to promote creativity and opportunities for science and innovation that are socially desirable and undertaken in the public interest. Responsible Innovation acknowledges, that innovation can raise questions and dilemmas, is often ambiguous in terms of purposes and motivations and unpredictable in terms of impacts, beneficial or otherwise. Responsible Innovation creates spaces and processes to explore these aspects of innovation in an open, inclusive and timely way. This is a collective responsibility, where funders, researchers, stakeholders and the public all have an important role to play. It includes, but goes beyond, considerations of risk and regulation, important though these are.

As a public funder of research, we have a responsibility to ensure that our activities and the research we fund, are aligned with the principles of Responsible Innovation, creating value for society in an ethical and responsible way. EPSRC does not wish to be prescriptive about how Responsible Innovation is embedded in the research and innovation process. We recognise that some researchers are already well engaged

ANTICIPATE, REFLECT, ENGAGE AND ACT (AREA)

A Responsible Innovation approach should be one that continuously seeks to:

Anticipate – describing and analysing the impacts, intended or otherwise, (e.g. economic, social, environmental) that might arise. This does not seek to predict but rather to support an exploration of possible impacts and implications that may otherwise remain uncovered and little discussed.

Reflect – reflecting on the purposes of, motivations for and potential implications of the research, and the associated uncertainties, areas of ignorance, assumptions, framings, questions, dilemmas and social transformations these may bring.

Engage – opening up such visions, impacts and questioning to broader deliberation, dialogue, engagement and debate in an inclusive way.

Act – using these processes to influence the direction and trajectory of the research and innovation process itself.

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Research Policy

journal homepage: www.elsevier.com/locate/respol

Developing a framework for responsible innovation☆

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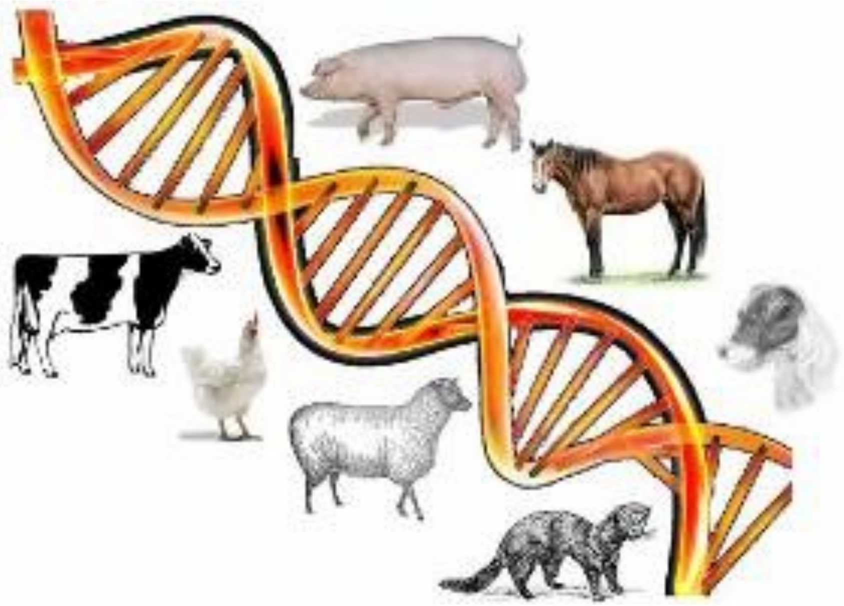
Just Editing:

A Comparative Responsible Innovation Approach to Animal Genome Editing



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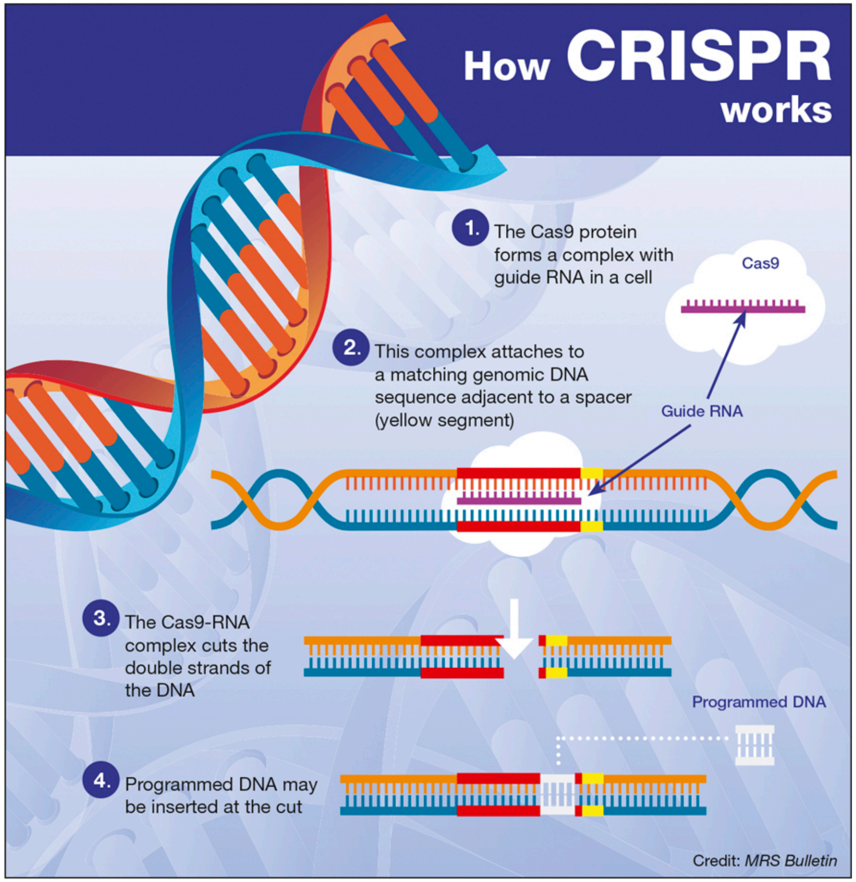
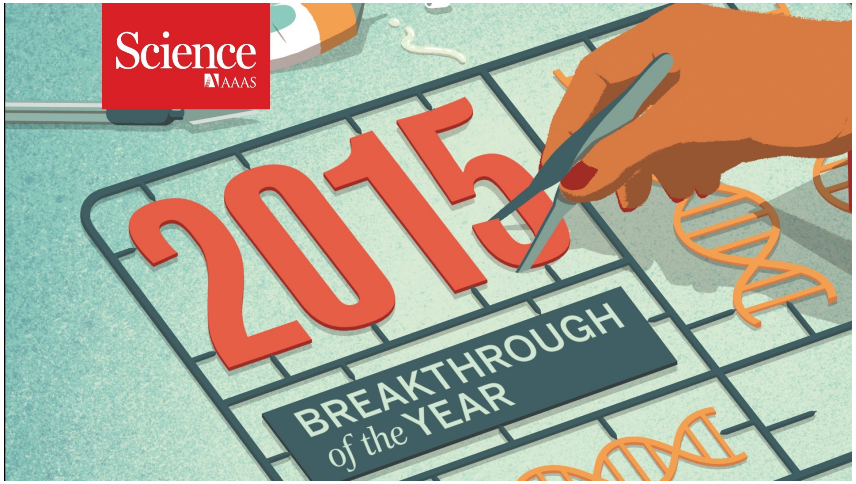
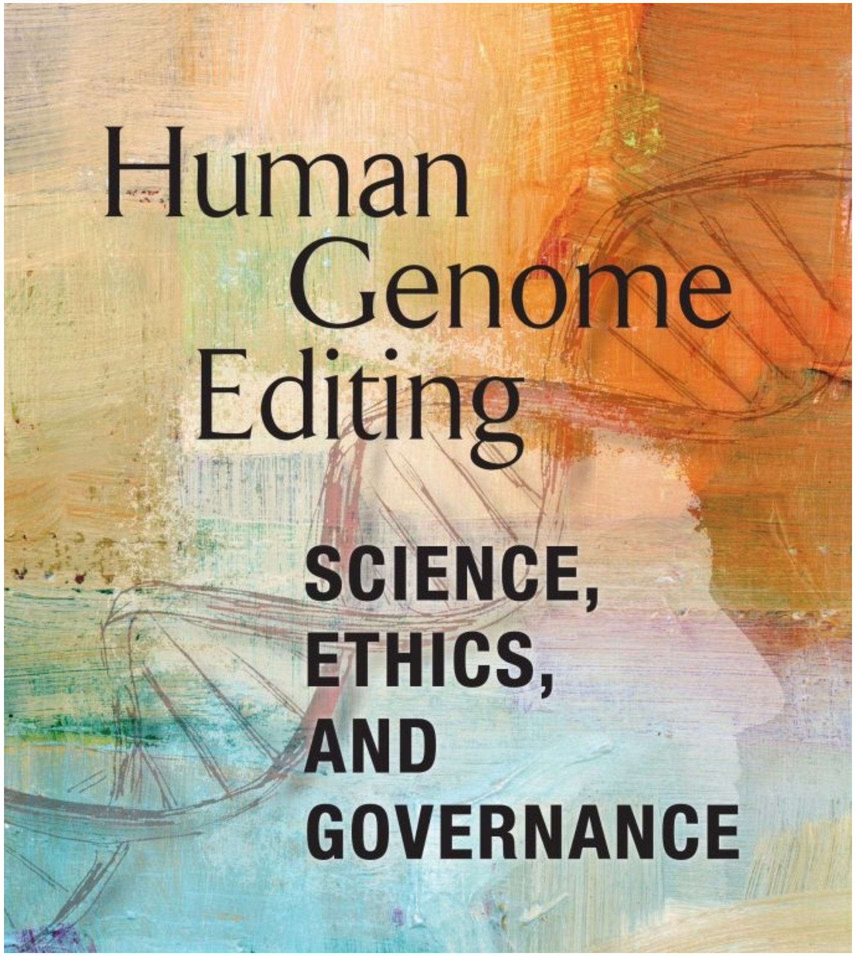
The science


How CRISPR works
1. The Cas9 protein forms a complex with guide RNA in a cell
Cas9
2. This complex attaches to a matching genomic DNA sequence adjacent to a spacer (yellow segment)
Guide RNA
3. The Cas9-RNA complex cuts the double strands of the DNA
Programmed DNA
4. Programmed DNA may be inserted at the cut
Credit: *MRS Bulletin*


Science
AAAS
2015
BREAKTHROUGH of the YEAR

The science



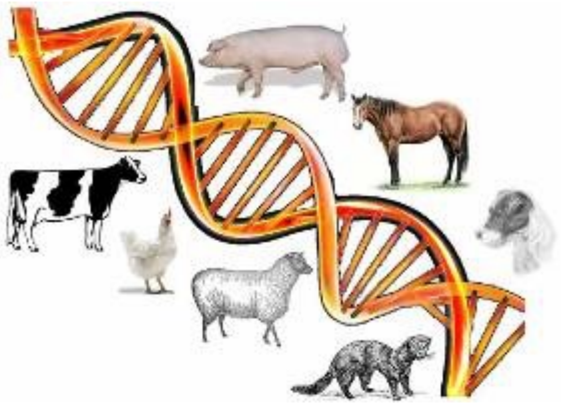
the CRISPR-Cas system – "has made editing of the genome much more precise, efficient, flexible, and less expensive relative to previous strategies" (National Academy of Sciences 2017: 1)

The promise (and the challenge)

"The technology has **excited interest** across the globe because of the **insights** it may offer into **fundamental biological processes** and the advances it may bring to human health. But with these advances come many questions, about the technical aspects of **achieving desired results** while **avoiding unwanted effects**, and about a range of uses that may include not only **healing the sick**, but also **preventing disease in this and future generations**, or even **altering traits unrelated to health needs**. Now is the time to consider these questions."

Applications in animal breeding

- Efficiency/ improvements in yield,
  - gains in reproductive efficiency e.g. chickens that produce only female offspring for egg laying)
  - edited animals that make more efficient conversion of inputs into outputs (e.g. pigs that can be fattened with less food through improved gut function)



- Health/ welfare of animals
  - adaption of livestock to the demands of intensive rearing practices (e.g. ‘hornless’ edited cows that can be kept in close proximity in confined spaces with less risk of injury)
- Disease resistance
  - through breeding resistance to viral pathogens (e.g. to breed pigs with resistance to African swine fever virus) or to engineer disease resistance to reduce the use of prophylactic antimicrobials in farming

Deep residues of trauma from GM crop and food controversy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Our research

“to examine the conditions (if any) under which the the technique of genome editing can and should be applied to animal breeding applications to guide responsive decision-making for scientists, breeders and government”

Workpackage 1: Anticipation and contextualisation

(Months 1-10)

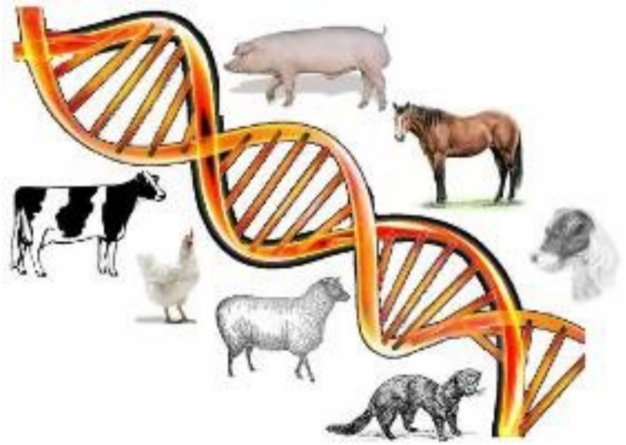
Task 1: Review of debate on science, governance and ethics of genome editing (human and animal)

Task 2: Comparison of animal breeding with human health applications (development of analytical framework)

Task 3: The expectations of genome editing in scientific and commercial programmes (animal genetics)

Task 4: Expert deliberation on safety, regulation and governance (animal genetics)

Workpackage 1: Anticipation and contextualisation



- Why have previous innovations in the new genetics have enjoyed differential societal and ethical acceptability?
- What can we learn from the controversy of GM foods and crops?
- What are the safety, regulation and governance challenges framed by different actors (scientists, policymakers, civil society)

Workpackage 2: Ethical reflection and public dialogue

(Months 8-16)

Task 1: Developing an ethical framework

Task 2: Designing and facilitating a public engagement methodology

Task 3: Analysing and interpreting the public focus groups

- An ethical framework
  - risk, safety, welfare, animal integrity, political economy, justice, instrumentalisation, naturalness, trust, hubris, relationality and telos
- Dialogue methodology
  - design principles of ‘upstream’ public engagement
  - publics segmented by extant relationships to animals
- Analysis
  - cultural narratives

Workpackage 3: Integration into research

(Months 14-24)

Task 1: Review of techniques aimed at building reflexivity into scientific practice

Task 2: Experiments in an academic animal science lab

Task 3: Experiments in four corporate breeding lab

Task 4: Policy seminar

- Techniques
  - to help animal scientists and breeders reflect upon the social and ethical dimensions of their research
- Toolkit
  - to help guide decision-making on how to think about decision-making on animal genome editing

How to communicate with society?

Questions for discussion

- Where are you on the responsibility ladder?
  - responsibility 1.0, 2.0 or 3.0
  - where do you need to be?
- What capacities do you need to cultivate?
  - anticipation-inclusion-reflexivity-responsiveness
  - How will you do this?
- With whom do you need to collaborate?
  - social scientists, ethicists, public dialogue specialists, anthropologists, theologians, civil society actors, governance specialists, regulators

Thank you!