Introduction to the RRI perspective: what it is about and how it emerged within the EU research policy

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From RRI to Open Science
Udine, January 30th, 2020

CNR – RRI: a long history of relationships

2014 Italian Presidency of the Council of the European Union

Friday, 21 November 2014

Rome Declaration on Responsible Research and Innovation in Europe

Responsible Research and Innovation (RRI) is the on-going process of aligning research and innovation to the values, needs and expectations of society.

Decisions in research and innovation must consider the principles on which the European Union is founded, i.e. the respect of human dignity, freedom, democracy, equality, the rule of law and the respect of human rights, including the rights of persons belonging to minorities.

RRI requires that all stakeholders including civil society are responsive to each other and take shared responsibility for the processes and outcomes of research and innovation. This means working together in: science education; the definition of research agendas; the conduct of research; the access to research results; and the application of new knowledge in society- in full respect of gender equality, the gender dimension in research and ethics considerations[1].

More than a decade of research and pilot activities on the interplay between science and society points to three main findings. First, we cannot achieve technology acceptance by way of good marketing. Second, diversity in research and innovation as well as the gender perspective is vital for enhancing creativity and improving scientific quality. And third, early and continuous engagement of all stakeholders is essential for sustainable, desirable and acceptable innovation.

Rome Declaration, 2014

EFARRI Bruxelles, 2016

CNR AIRI Report, 2015

A new bet for scientists? 2018

RRI: what is it, and how will we talk about it?

- RRI as an APPROACH to the relationship science-technology-society-policy: WHAT, WHY, HOW did RRI EMERGE in the EUROPEAN POLICY?
- The EPISTEMOLOGICAL and SOCIAL ROOTS OF RRI
- Some PRACTICAL AND REFLEXIVE TOOLS

RRI: what is it, and how will we talk about it?

- RRI is a recent acronym but considerations on the role of science in society are not new
- Implementing RRI implies challenges and risks (new «bureaucracy of virtues» (Felt) or a question of protocol?
- RRI as a «legitimisation to own activities», «license to operate» (Rip)?
- Responsibility in science and society is not a prerogative of RRI (critical views)
- RRI is not a magic formula but a dynamic open-ended concept (Rip): each one has its own way to RRI

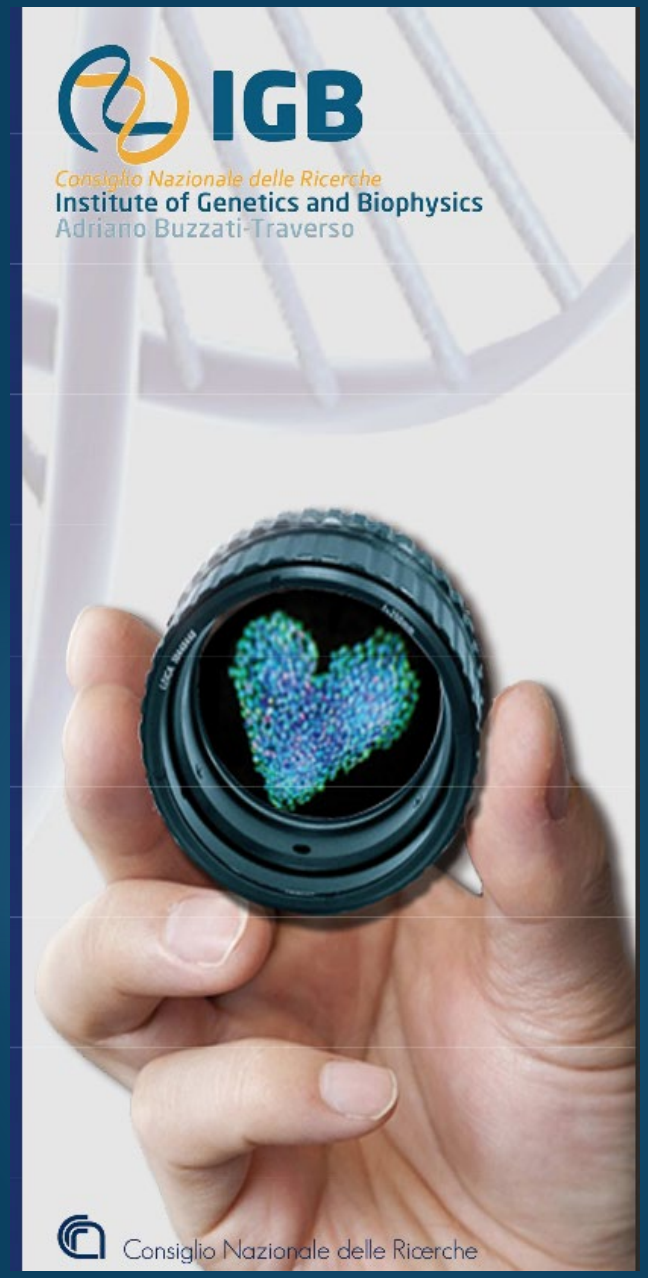
RRI: what is it, and how will we talk about it?

- Reflections from personal expertise and experiences
- Finding from studies, lesson learnt, case studies
- Readings, videos
- Conversations, lab activities

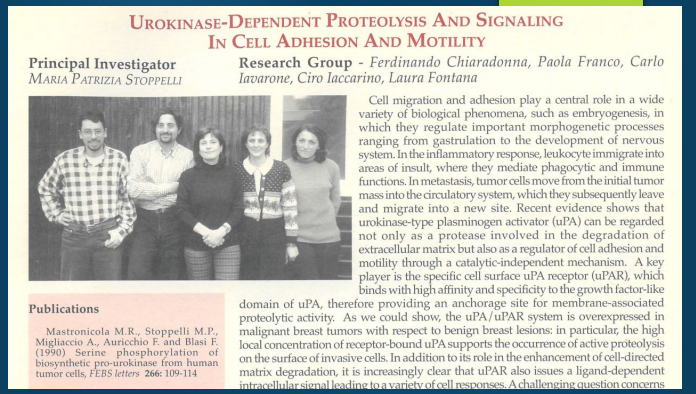
A process of mutual learning towards a co-construction of knowledge

How did I first meet RRI?

Or… the contribute of social sciences and science communication towards the redefinition of the relationship between science and society and RRI



Personal experience #1



Urokinase-Dependent Proteolysis And Signaling In Cell Adhesion And Motility

Principal Investigator
Maria Patrizia Stoppelli

Research Group - *Ferdinando Chiaradonna, Paola Franco, Carlo Iavarone, Ciro Iaccarino, Laura Fontana*

Cell migration and adhesion play a central role in a wide variety of biological phenomena, such as embryogenesis, in which they regulate important morphogenetic processes ranging from gastrulation to the development of nervous system. In the inflammatory response, leukocyte immigrate into areas of insult, where they mediate phagocytic and immune functions. In metastasis, tumor cells move from the initial tumor mass into the circulatory system, which they subsequently leave and migrate into a new site. Recent evidence shows that urokinase-type plasminogen activator (uPA) can be regarded not only as a protease involved in the degradation of extracellular matrix but also as a regulator of cell adhesion and motility through a catalytic-independent mechanism. A key player is the specific cell surface uPA receptor (uPAR), which binds with high affinity and specificity to the growth factor-like domain of uPA, therefore providing an anchorage site for membrane-associated proteolytic activity. As we could show, the uPA/uPAR system is overexpressed in malignant breast tumors with respect to benign breast lesions: in particular, the high local concentration of receptor-bound uPA supports the occurrence of active proteolysis on the surface of invasive cells. In addition to its role in the enhancement of cell-directed matrix degradation, it is increasingly clear that uPAR also issues a ligand-dependent intracellular signal leading to a variety of cell responses. A challenging question concerns

Publications

Mastronicola M.R., Stoppelli M.P., Migliaccio A., Auricchio F. and Blasi F. (1990) Serine phosphorylation of biosynthetic pro-urokinase from human tumor cells, *FEBS letters* **266**: 109-114

Late Events During Sporulation Of *Bacillus Subtilis*: σ^K Activation And Expression Of *Cot* Genes

Principal Investigator
Margherita Sacco

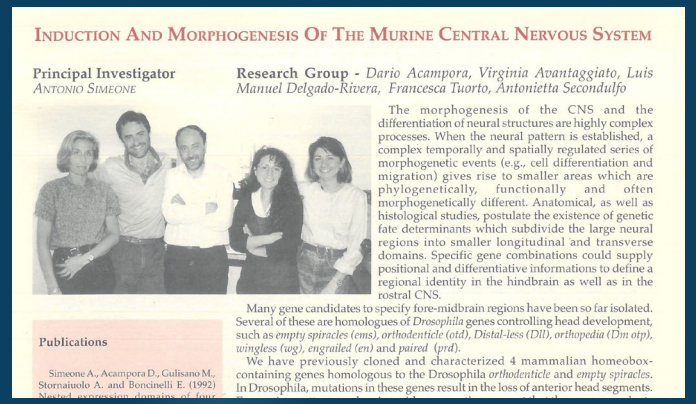
Research Group - *Maurilio De Felice, Rosangela Marasco, Cond Sole, Mario Varcamonti*

The sporulation process in *Bacillus subtilis* involves expressio hundred of genes and the formation of two cells, the forespore, w becomes the mature spore characterised by multiple resista properties, and the mother cell, which, at completion of sporulation cycle, lyses releasing the spore. The global regula network that controls sporulation relies on the successive appeara of 4 sigma factors, σ^F and σ^G active in the forespore, and σ^E and active in the mother cell.

We are interested in the understanding of late events of sporulation cycle: the activation of pro-σ^K and the subsequent σ^K-dri gene expression. The primary product of the *sigK* gene, coding for σ^K a pro-protein, pro-σ^K. Conversion of the inactive pro-σ^K to its active fo is under the control of a specific protease, SpoIVFB, and represent checkpoint that couples gene expression in the mother cell to development of the forespore. σ^K is responsible for the transcription genes coding for structural components of the spore coat. Earlier express of σ^K results in the formation of spores, strongly impaired in th germination efficiency, indicating that a very precise temporal control pro-σ^K processing is necessary to ensure expression of the Cot proteins at the corr time. The activity of SpoIVFB is under the control of two regulatory proteins, SpoIV and BofA. It has been proposed that these three proteins form an heterotrimeric compl in the outer forespore membrane. The two regulatory components of th

Publications

Naclerio G., Ricca E., Sacco M. and De Felice M. (1993) Antimicrobial



Induction And Morphogenesis Of The Murine Central Nervous System

Principal Investigator
Antonio Simeone

Research Group - *Dario Acampora, Virginia Avantaggiato, Luis Manuel Delgado-Rivera, Francesca Tuorto, Antonietta Secondulfo*

The morphogenesis of the CNS and the differentiation of neural structures are highly complex processes. When the neural pattern is established, a complex temporally and spatially regulated series of morphogenetic events (e.g., cell differentiation and migration) gives rise to smaller areas which are phylogenetically, functionally and often morphogenetically different. Anatomical, as well as histological studies, postulate the existence of genetic fate determinants which subdivide the large neural regions into smaller longitudinal and transverse domains. Specific gene combinations could supply positional and differentiative informations to define a regional identity in the hindbrain as well as in the rostral CNS.

Many gene candidates to specify fore-midbrain regions have been so far isolated. Several of these are homologues of *Drosophila* genes controlling head development, such as *empty spiracles (ems)*, *orthodenticle (otd)*, *Distal-less (Dll)*, *orthopedia (Dm otp)*, *wingless (wg)*, *engrailed (en)* and *paired (prd)*.

We have previously cloned and characterized 4 mammalian homeobox-containing genes homologous to the Drosophila *orthodenticle* and *empty spiracles*. In Drosophila, mutations in these genes result in the loss of anterior head segments.

Publications

Simeone A., Acampora D., Gulisano M., Stornaiuolo A. and Boncinelli E. (1992)

RRI process always starts from

good questions

"The kind of questions that public typically ask scientists, or would like to see scientists ask of themselves"

(Stilgoe, Owen, and Macnaghten 2013)

How does your research contribute to (which) societal problem?

How and to what extent do you want to involve (which) audiences?

What roles do you give to them? How will you acknowledge their contribution?

How will this impact on your research?

patients children

families doctors

collaborative research

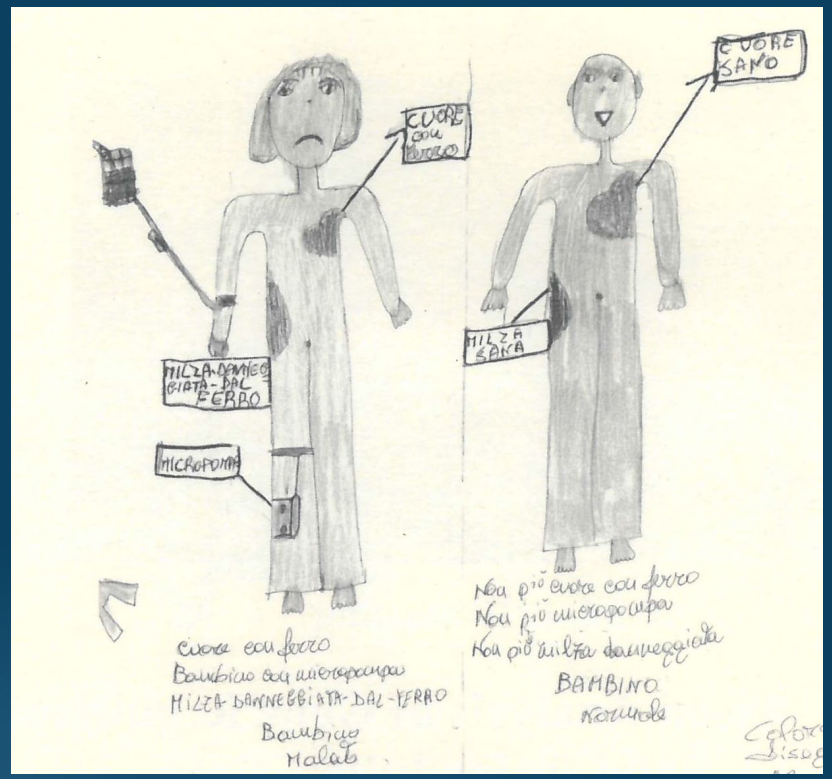
School in Hospital

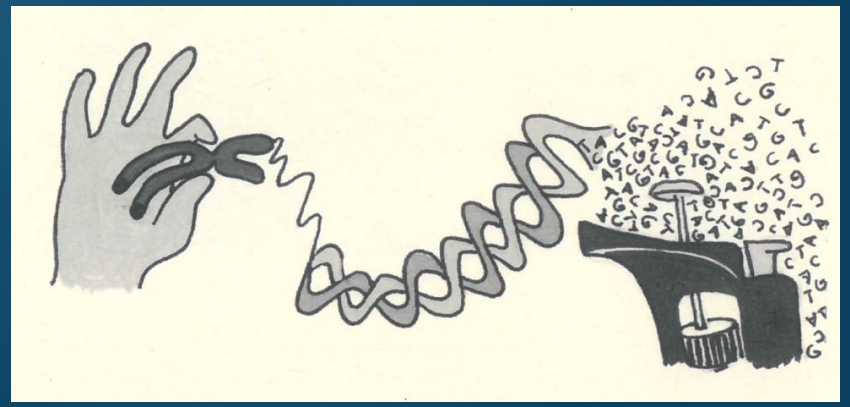
cure-vs-care

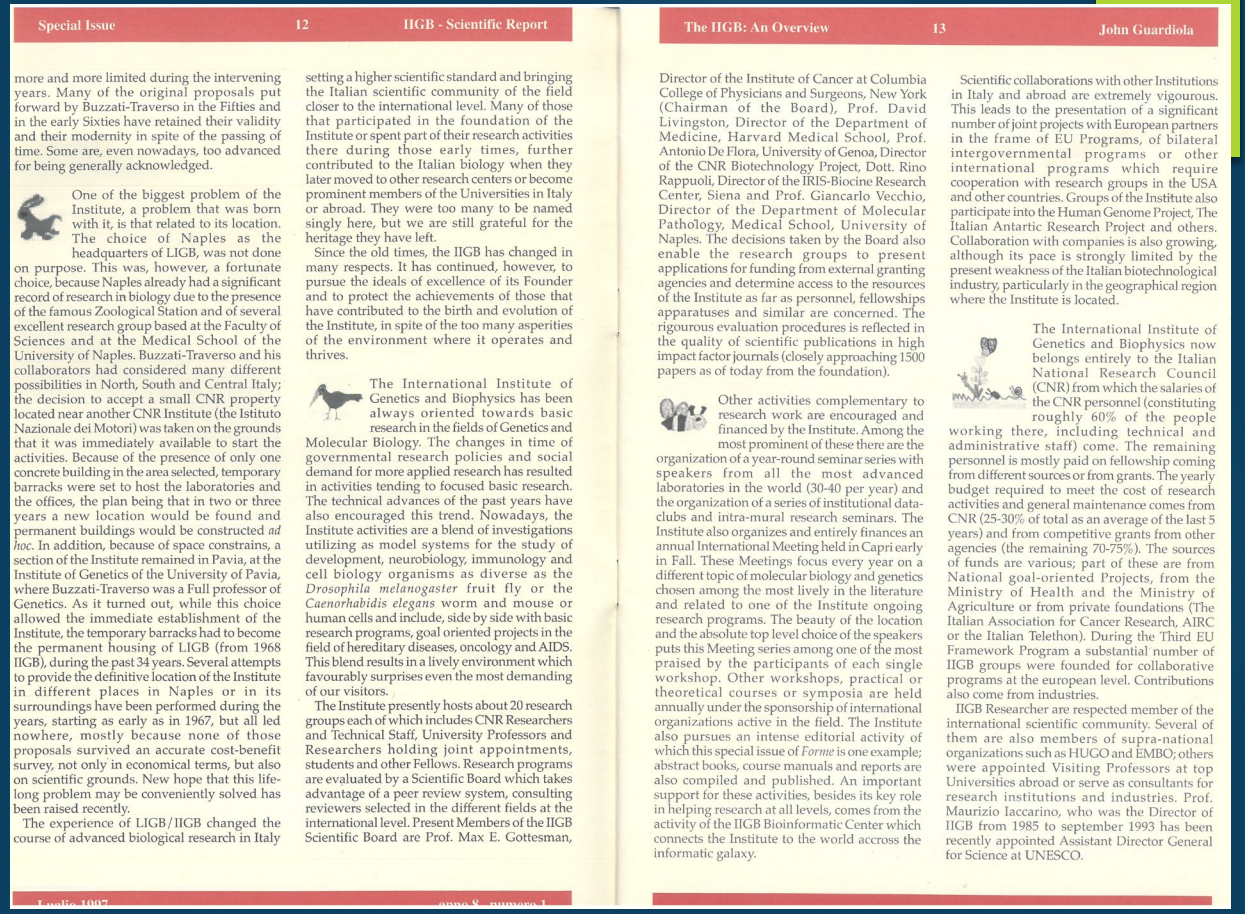
mutual learning

future visions trust

drawings from "School in Hospital" - Hematology and Bone Marrow Transplantation Institute at the Pesaro Hospital







Special Issue 12 IIGB - Scientific Report

more and more limited during the intervening years. Many of the original proposals put forward by Buzzati-Traverso in the Fifties and in the early Sixties have retained their validity and their modernity in spite of the passing of time. Some are, even nowadays, too advanced for being generally acknowledged.

One of the biggest problem of the Institute, a problem that was born with it, is that related to its location. The choice of Naples as the headquarters of LIGB, was not done on purpose. This was, however, a fortunate choice, because Naples already had a significant record of research in biology due to the presence of the famous Zoological Station and of several excellent research group based at the Faculty of Sciences and at the Medical School of the University of Naples. Buzzati-Traverso and his collaborators had considered many different possibilities in North, South and Central Italy; the decision to accept a small CNR property located near another CNR Institute (the Istituto Nazionale dei Motori) was taken on the grounds that it was immediately available to start the activities. Because of the presence of only one concrete building in the area selected, temporary barracks were set to host the laboratories and the offices, the plan being that in two or three years a new location would be found and permanent buildings would be constructed *ad hoc*. In addition, because of space constrains, a section of the Institute remained in Pavia, at the Institute of Genetics of the University of Pavia, where Buzzati-Traverso was a Full professor of Genetics. As it turned out, while this choice allowed the immediate establishment of the Institute, the temporary barracks had to become the permanent housing of LIGB (from 1968 IIGB), during the past 34 years. Several attempts to provide the definitive location of the Institute in different places in Naples or in its surroundings have been performed during the years, starting as early as in 1967, but all led nowhere, mostly because none of those proposals survived an accurate cost-benefit survey, not only in economical terms, but also on scientific grounds. New hope that this life-long problem may be conveniently solved has been raised recently.

The experience of LIGB/IIGB changed the course of advanced biological research in Italy setting a higher scientific standard and bringing the Italian scientific community of the field closer to the international level. Many of those that participated in the foundation of the Institute or spent part of their research activities there during those early times, further contributed to the Italian biology when they later moved to other research centers or become prominent members of the Universities in Italy or abroad. They were too many to be named singly here, but we are still grateful for the heritage they have left.

Since the old times, the IIGB has changed in many respects. It has continued, however, to pursue the ideals of excellence of its Founder and to protect the achievements of those that have contributed to the birth and evolution of the Institute, in spite of the too many asperities of the environment where it operates and thrives.

The International Institute of Genetics and Biophysics has been always oriented towards basic research in the fields of Genetics and Molecular Biology. The changes in time of governmental research policies and social demand for more applied research has resulted in activities tending to focused basic research. The technical advances of the past years have also encouraged this trend. Nowadays, the Institute activities are a blend of investigations utilizing as model systems for the study of development, neurobiology, immunology and cell biology organisms as diverse as the *Drosophila melanogaster* fruit fly or the *Caenorhabidis elegans* worm and mouse or human cells and include, side by side with basic research programs, goal oriented projects in the field of hereditary diseases, oncology and AIDS. This blend results in a lively environment which favourably surprises even the most demanding of our visitors.

The Institute presently hosts about 20 research groups each of which includes CNR Researchers and Technical Staff, University Professors and Researchers holding joint appointments, students and other Fellows. Research programs are evaluated by a Scientific Board which takes advantage of a peer review system, consulting reviewers selected in the different fields at the international level. Present Members of the IIGB Scientific Board are Prof. Max E. Gottesman,

The IIGB: An Overview 13 John Guardiola

Director of the Institute of Cancer at Columbia College of Physicians and Surgeons, New York (Chairman of the Board), Prof. David Livingston, Director of the Department of Medicine, Harvard Medical School, Prof. Antonio De Flora, University of Genoa, Director of the CNR Biotechnology Project, Dott. Rino Rappuoli, Director of the IRIS-Biocine Research Center, Siena and Prof. Giancarlo Vecchio, Director of the Department of Molecular Pathology, Medical School, University of Naples. The decisions taken by the Board also enable the research groups to present applications for funding from external granting agencies and determine access to the resources of the Institute as far as personnel, fellowships apparatuses and similar are concerned. The rigourous evaluation procedures is reflected in the quality of scientific publications in high impact factor journals (closely approaching 1500 papers as of today from the foundation).

Other activities complementary to research work are encouraged and financed by the Institute. Among the most prominent of these there are the organization of a year-round seminar series with speakers from all the most advanced laboratories in the world (30-40 per year) and the organization of a series of institutional data-clubs and intra-mural research seminars. The Institute also organizes and entirely finances an annual International Meeting held in Capri early in Fall. These Meetings focus every year on a different topic of molecular biology and genetics chosen among the most lively in the literature and related to one of the Institute ongoing research programs. The beauty of the location and the absolute top level choice of the speakers puts this Meeting series among one of the most praised by the participants of each single workshop. Other workshops, practical or theoretical courses or symposia are held annually under the sponsorship of international organizations active in the field. The Institute also pursues an intense editorial activity of which this special issue of *Forme* is one example; abstract books, course manuals and reports are also compiled and published. An important support for these activities, besides its key role in helping research at all levels, comes from the activity of the IIGB Bioinformatic Center which connects the Institute to the world accross the informatic galaxy.

Scientific collaborations with other Institutions in Italy and abroad are extremely vigourous. This leads to the presentation of a significant number of joint projects with European partners in the frame of EU Programs, of bilateral intergovernmental programs or other international programs which require cooperation with research groups in the USA and other countries. Groups of the Institute also participate into the Human Genome Project, The Italian Antartic Research Project and others. Collaboration with companies is also growing, although its pace is strongly limited by the present weakness of the Italian biotechnological industry, particularly in the geographical region where the Institute is located.

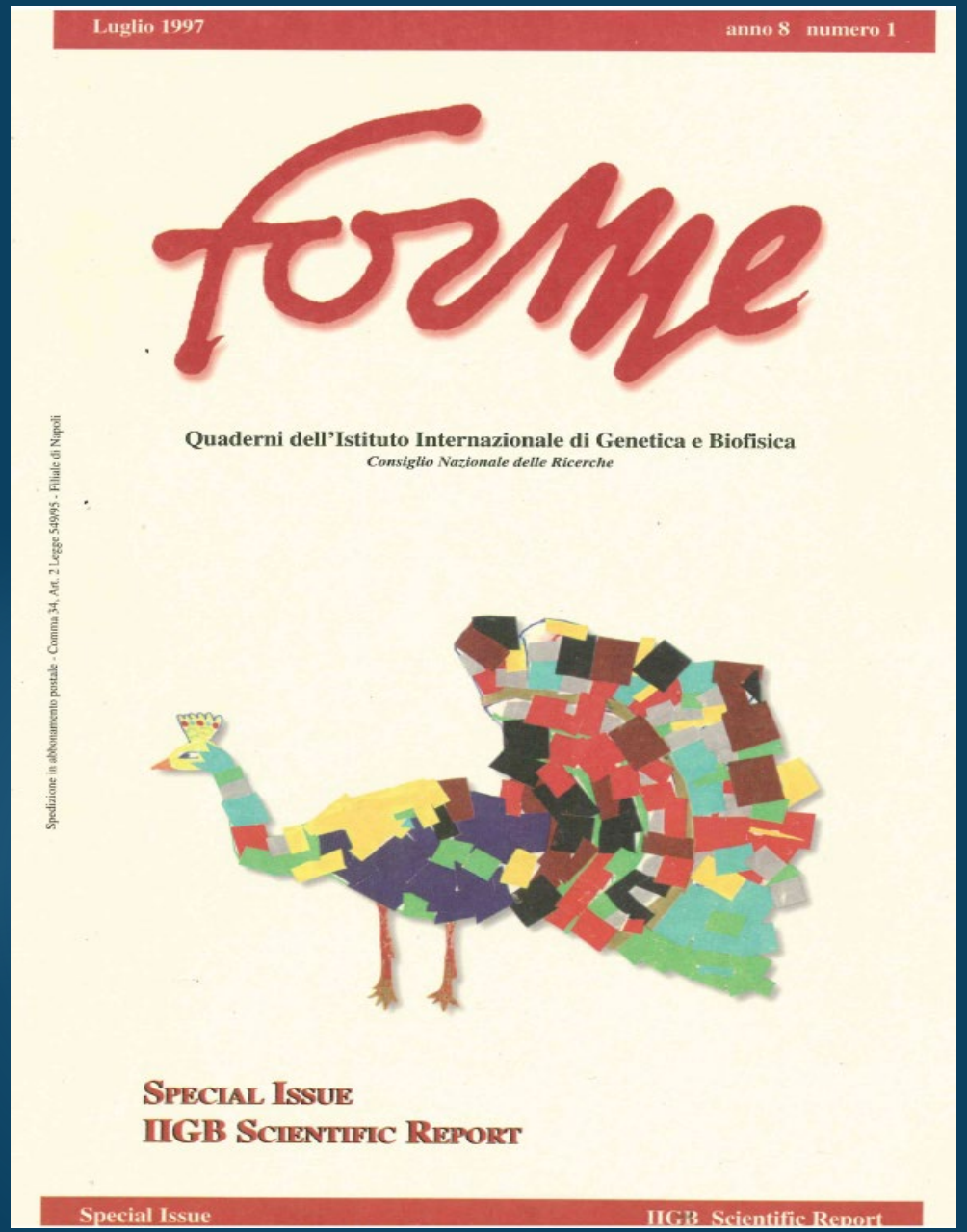
The International Institute of Genetics and Biophysics now belongs entirely to the Italian National Research Council (CNR) from which the salaries of the CNR personnel (constituting roughly 60% of the people working there, including technical and administrative staff) come. The remaining personnel is mostly paid on fellowship coming from different sources or from grants. The yearly budget required to meet the cost of research activities and general maintenance comes from CNR (25-30% of total as an average of the last 5 years) and from competitive grants from other agencies (the remaining 70-75%). The sources of funds are various; part of these are from National goal-oriented Projects, from the Ministry of Health and the Ministry of Agriculture or from private foundations (The Italian Association for Cancer Research, AIRC or the Italian Telethon). During the Third EU Framework Program a substantial number of IIGB groups were founded for collaborative programs at the european level. Contributions also come from industries.

IIGB Researcher are respected member of the international scientific community. Several of them are also members of supra-national organizations such as HUGO and EMBO; others were appointed Visiting Professors at top Universities abroad or serve as consultants for research institutions and industries. Prof. Maurizio Iaccarino, who was the Director of IIGB from 1985 to september 1993 has been recently appointed Assistant Director General for Science at UNESCO.

drawings from "School in Hospital" - Hematology and Bone Marrow Transplantation Institute at the Pesaro Hospital

Genetic Content And Sequence Analysis Of Human Xq28

An ideal process of RRI



- Involves different ACTORS around a societal challenge
- Each actor brings her/his PERSPECTIVE (not only facts, but values, identities, emotions, knowledge, languages, visions)
- Mutual TRUST and RESPONSABILITY
- CREATIVITY (thinking out the box) in finding new FORMS of collaboration can help a lot in the relationship

Finally came RRI

Responsible Research and Innovation (RRI) means that societal actors work together during the whole research and innovation process in order to better align both the process and its outcomes, with the values, needs and expectations of European society.
RRI is an ambitious challenge for the creation of a Research and Innovation policy driven by the needs of society and engaging all societal actors via inclusive participatory approaches.

(European Commission 2012)

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).

Von Schonberg 2013)

RRI is the on-going process (…) that requires that all stakeholders including civil society are responsive to each other and take shared responsibility for the processes and outcomes of research and innovation (…) working together in: science education; definition of research agendas; conduct of research; access to research results; application of new knowledge in society in full respect of gender equality, gender dimension in research and ethics considerations.

(Rome Declaration 2014)

But… what's NEW in RRI?

«The intensity with which these issues have been discussed, the prominence that science policy has had on political agendas and the breadth of reform processes that have been implemented in recent years, are far greater than in the past»

Mejlgaard and Bloch, 2012

Why should R&I be «Responsible»?

The reflections of the Science, Technology and Society studies, or the far roots of RRI

RRI is connected at least with three phenomena

- changes in science (and society) in time
- scientific innovation not associated with benefits but also with risks / danger / unethical and controversial issues (some lesson learnt)
- re-framing and re-understanding science (and society)

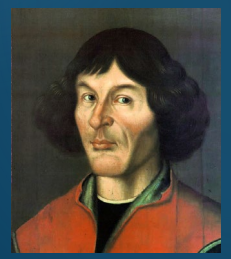
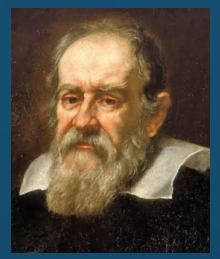
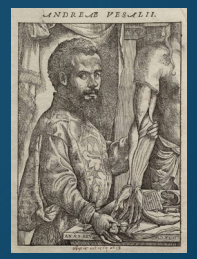
Re-understanding the science-society interplay

1600- today: different sciences? Different societies.

1600-1800: «Pioneer period»

Scientific revolution, first scientific societies.

- Differentiation from magic, refuse of secret;
- Adoption of the mathematic frame;
- Claim of complete autonomy from politics and religion.

1800-1945: «Academic period»

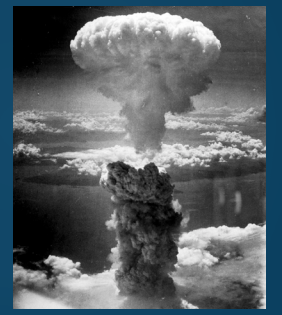
Science is a recognized profession, inside Universities; Governments don't intervene;

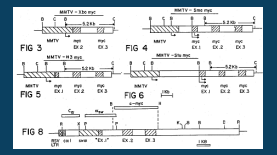
Humboldtian reformation of University.

- Decisions taken inside the scientific community;
- Establishment of labs as the natural places to do science;
- Differentiation and specialization among the disciplines;
- Trans-nationality;
- One common language: first Latin, then French and English.

1945- : «Post-Academic period»

Science: The Endless Frontier (1945) / A Program for the Nation (1947); Little to Big Science; '70s private research funding by private industries exceeds public funds.



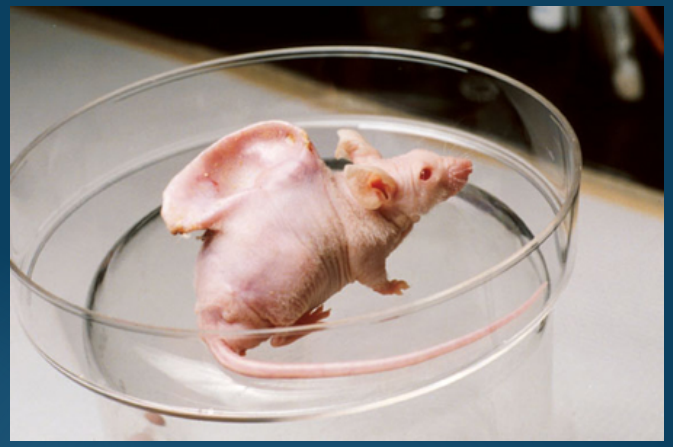
- Unprecedented financial and human resources;
- the scientific community is forced to take important decisions together with societal actors
- scientists "must" look for a difficult social consensus in political circles and public opinion;
- politicians are called upon to take important decisions for the development of science

Science & War

The Manhattan project: the first steps of a… modern industrial project management!

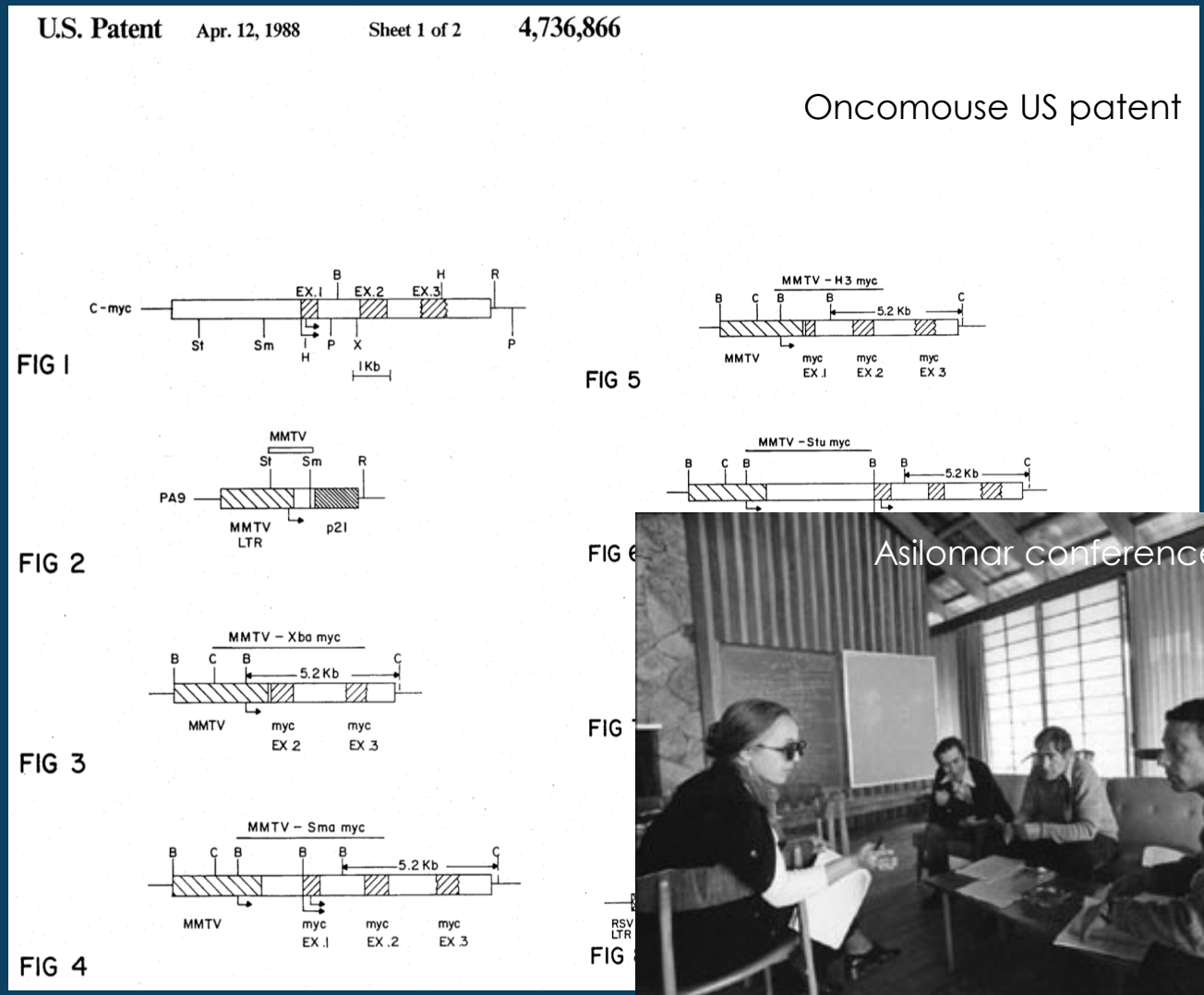
Taylorism applied to techno-scientific research

Understanding, manipulating and patenting life



Vacanti mouse, circa 1996

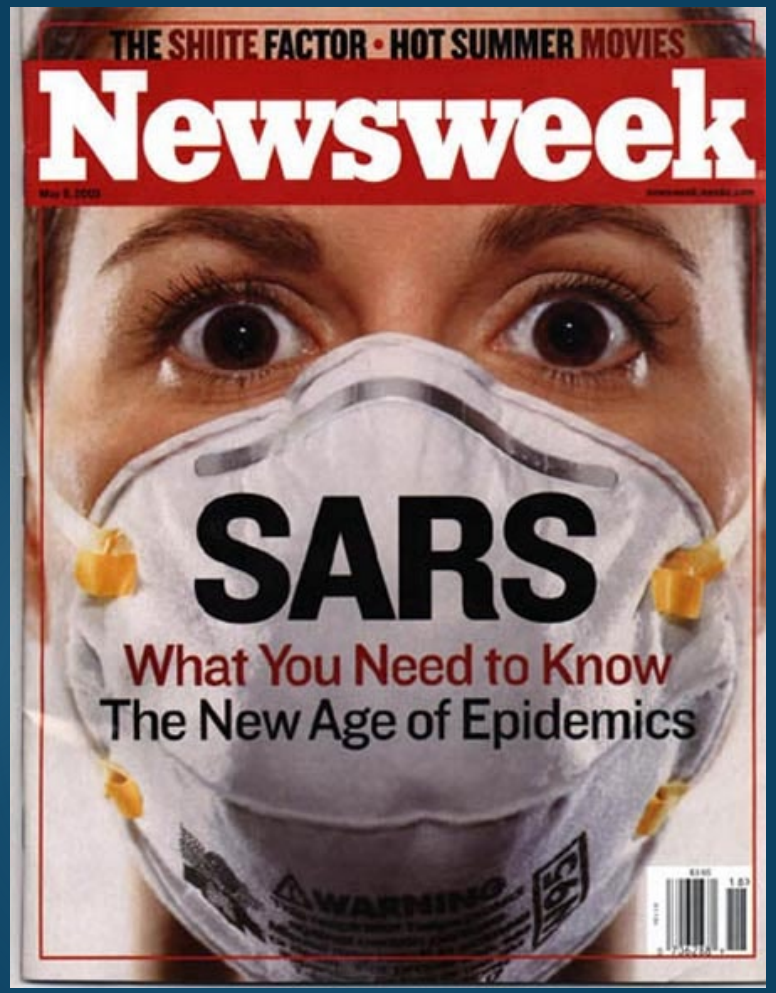
Human Genome decryption announcement, 2000

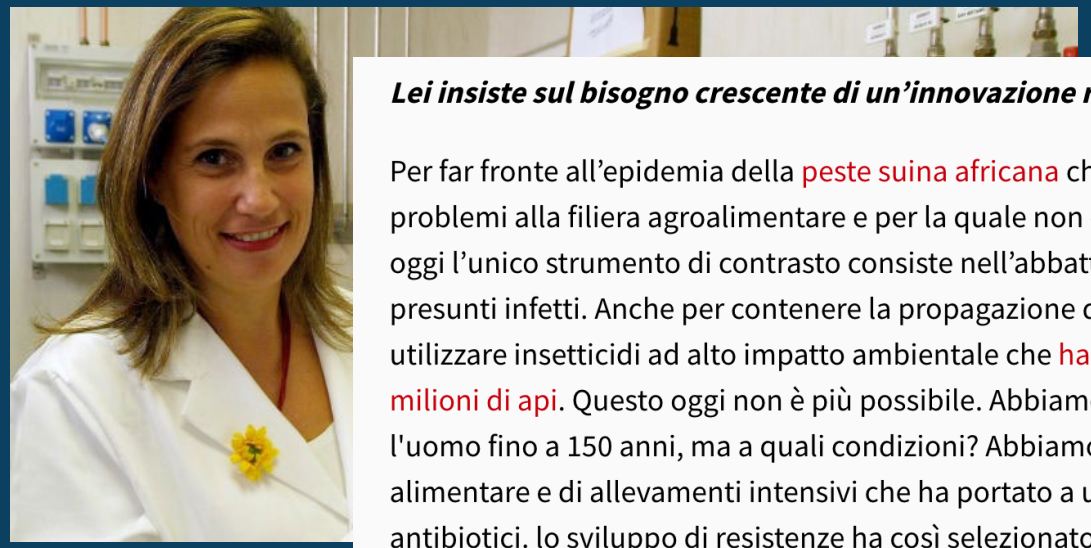


Oncomouse US patent

Asilomar conference, 1975

Circulating knowledge





Lei insiste sul bisogno crescente di un'innovazione responsabile. In che senso?

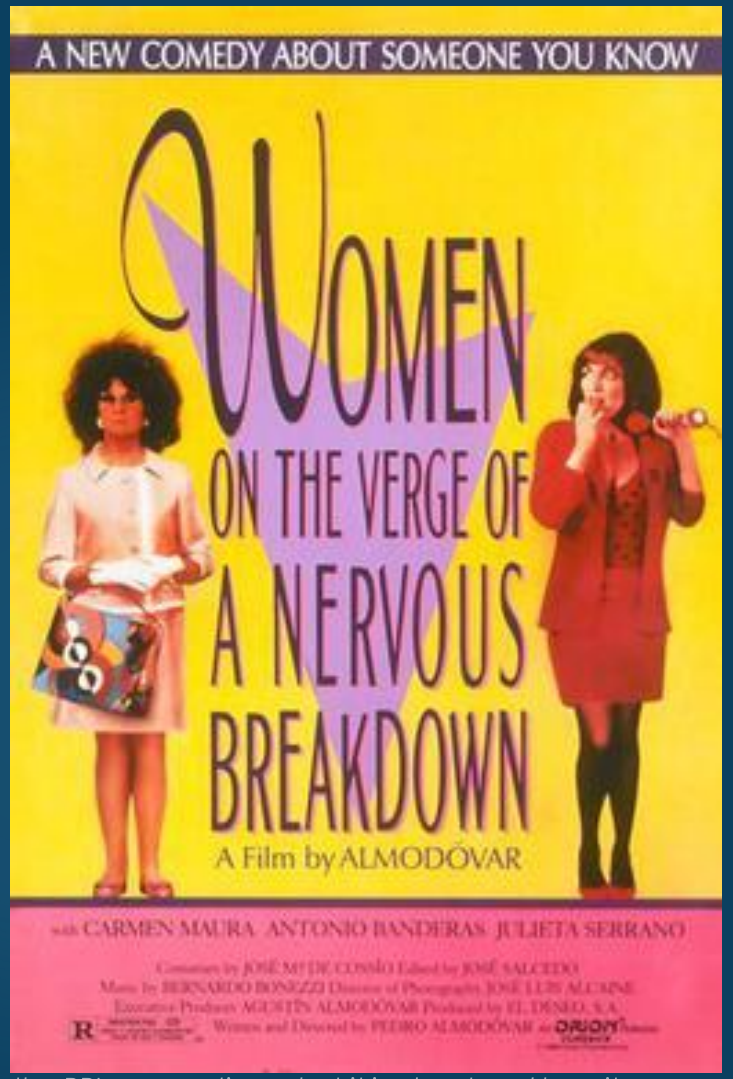
Per far fronte all'epidemia della peste suina africana che sta creando grandi problemi alla filiera agroalimentare e per la quale non esiste ancora un vaccino, a oggi l'unico strumento di contrasto consiste nell'abbattimento degli animali infetti o presunti infetti. Anche per contenere la propagazione di Zika è stato necessario utilizzare insetticidi ad alto impatto ambientale che hanno sterminato (anche) milioni di api. Questo oggi non è più possibile. Abbiamo l'ambizione di far vivere l'uomo fino a 150 anni, ma a quali condizioni? Abbiamo creato un sistema alimentare e di allevamenti intensivi che ha portato a un uso insostenibile degli antibiotici. lo sviluppo di resistenze ha così selezionato batteri superkiller che aumentano rischi sanitari e costi.

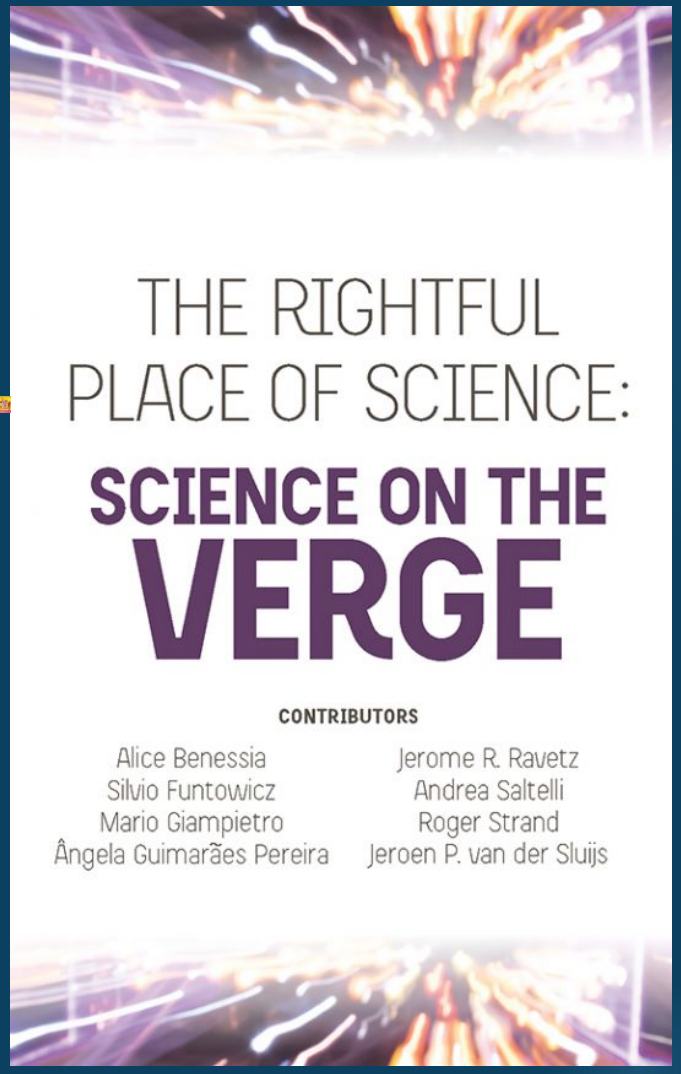
Su un diverso fronte, siamo diventati grandi generatori e consumatori di dati per i fini più disparati: dal controllo di quante calorie consumiamo alla presenza degli allergeni nei cibi che consumiamo. Grazie ai dati stiamo aumentando il nostro controllo su noi stessi, la casa, le città, il mondo. Ma questo grande vantaggio tecnologico resta cieco se non ci aggiungiamo quello che le macchine non ci possono dare: la responsabilità, l'etica.

Bogner, P., Capua, I., Lipman, D. *et al.* A global initiative on sharing avian flu data. *Nature* **442**, 981 (2006). https://doi.org/10.1038/442981a

https://www.scienzainrete.it/articolo/intervista-ilaria-capua-sola-salute/rosy-matrangolo/2018-12-13

Science on the verge

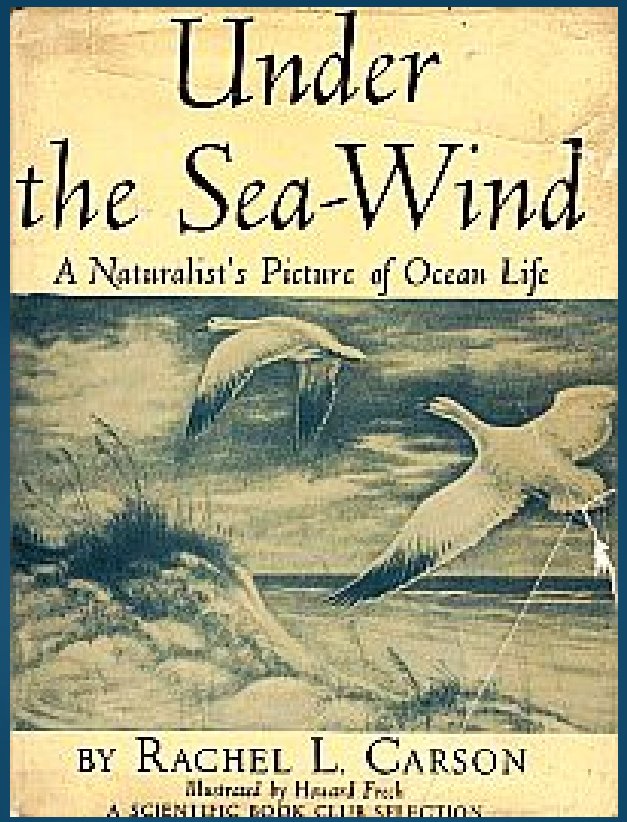


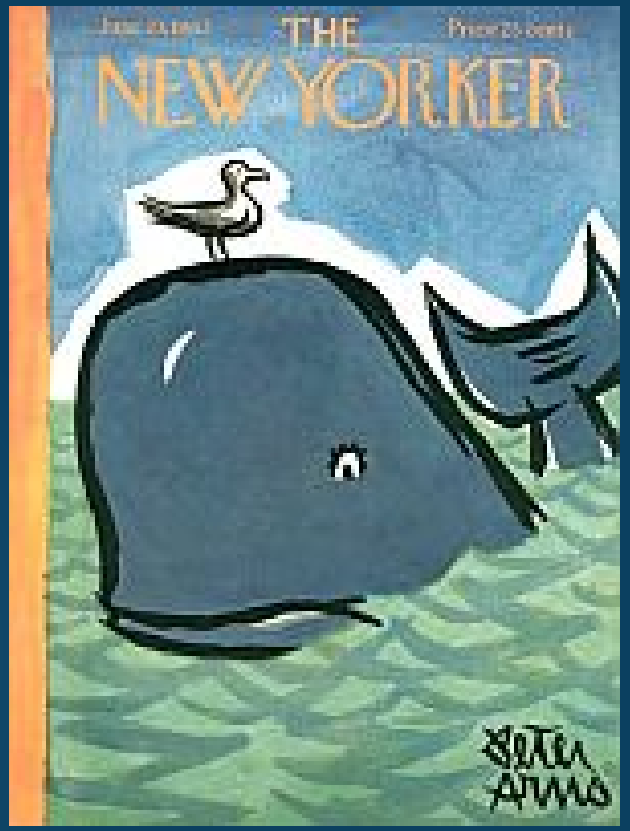


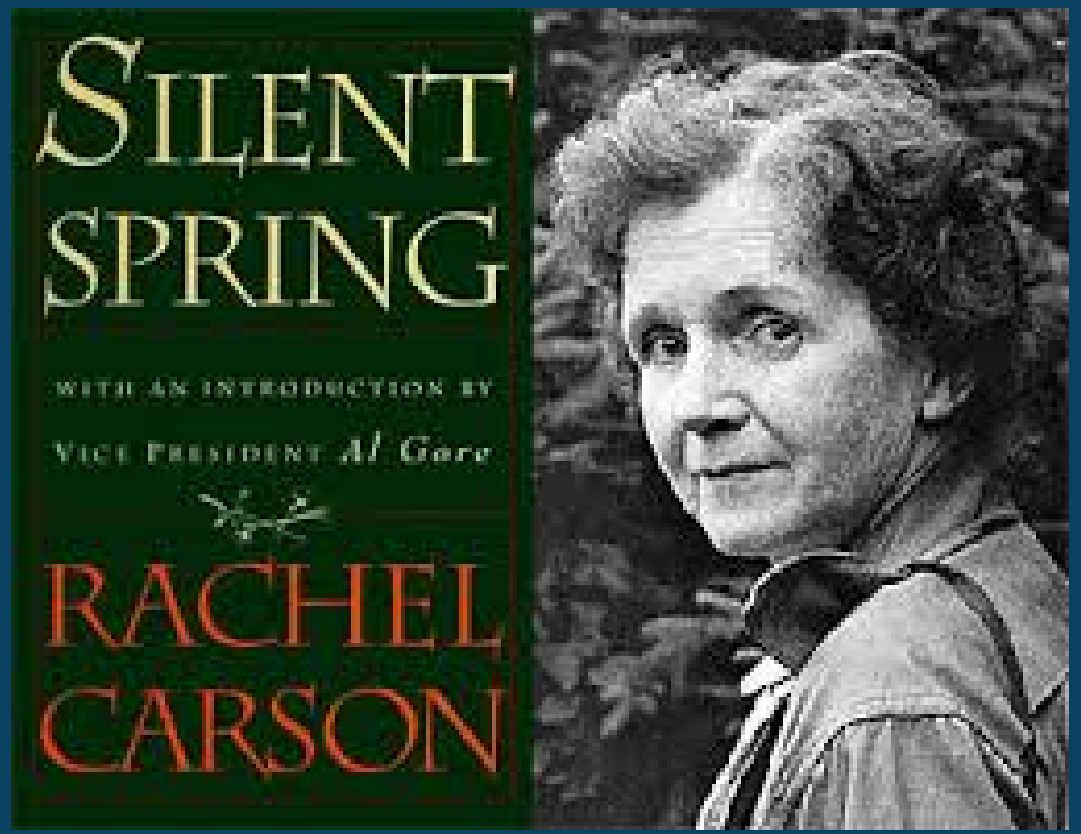
RRI lessons learnt

STORIES ABOUT *IRRESPONSIBLE* RESEARCH AND OF PEOPLE WHO CHALLENGED THE POLICY

Rachel Carson: the first gender perspective in the environmental studies







It is not my contention that chemical insecticides must never be used. I do contend that we have put poisonous and biologically potent chemicals indiscriminately into the hands of persons largely or wholly ignorant of their potentials for harm. We have subjected enormous numbers of people to contact with these poisons, without their consent and often without their knowledge. (…)

Future generations are unlikely to condone our lack of prudent concern for the integrity of the natural world that supports all life. (…)

This is an era of specialists, each of whom sees his own problem and is unaware of or intolerant of the larger frame into which it fits. It is also an era dominated by industry, in which the right to make a dollar at whatever cost is seldom challenged.

When the public protests, confronted with some obvious evidence of damaging results of pesticide applications, it is fed little tranquilizing pills of half truth. We urgently need an end to these false assurances, to the sugar coating of unpalatable facts. It is the public that is being asked to assume the risks that the insect controllers calculate. The public must decide whether it wishes to continue on the present road, and it can do so only when in full possession of the facts. (Rachel Carson, 1962, Silent Spring)

SEVESO (1976): lack of knowledge or of problem sharing?

«per capire, e per prevenire i rischi ambientali, bisogna andare ben oltre le pagine di un trattato di chimica… bisogna varcare la soglia della fabbrica e calarsi nella realtà della produzione…»

Bruna De Marchi

«Seveso non è stato un evento imprevedibile e unico, circoscrivibile in uno spazio e un tempo determinati. Le cause stanno nel colpevole disinteresse per i valori della salute e dell'ambiente, in negligenze e omissioni destinate ad aggravarne le conseguenze e a favorire il ripetersi di simili accadimenti.
Il problema non è la mancanza di conoscenza, quanto piuttosto la sua strumentalizzazione e non condivisione..»

Giulio Maccacaro

BSE (1986): how (NOT) to communicate uncertainty

The Minister of Agriculture, eating a beefburger with his daughter trying to convince the public 1990 (EPA)

Radioactive sheep (1986): WHO's the EXPERT?

Discrasy between the - abstract and sophisticated - estimates of the experts and the perception of the risk of contamination led farmers to lose their trust in government experts and to consider the assessments of the latter spoiled by the government's desire to "silence the story"

Bryan Wynne

Unconvenient questions: deconstructing the myths

Greenpeace protests at Downing Street

Key questions about the use of GMOs revealed by PABE:

Why do we need GMOs?

Who will benefit from their use?

Who decided that they should be developed and how?

Why were we not better informed about their use in our food, before their arrival on the market?

Why are we not given an effective choice about whether or not to buy these products?

Have potential long-term and irreversible consequences been seriously evaluated, and by whom?

Do regulatory authorities have sufficient powers to effectively regulate large companies who wish to develop these products?

Can controls imposed by regulatory authorities be applied effectively?

Who will be accountable in cases of unforeseen harm?

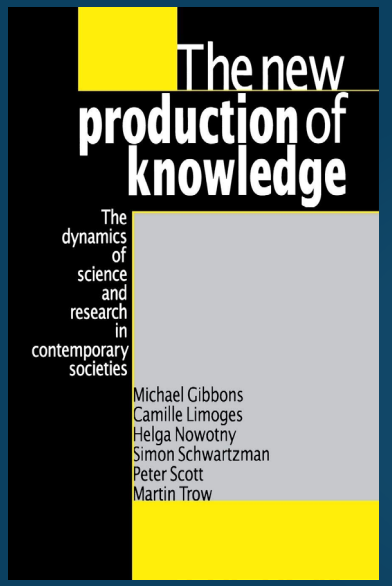
Claire Marris. 2001, «Stakeholders in the GMO debate often describe public opinion as irrational. But do they really understand the public?"

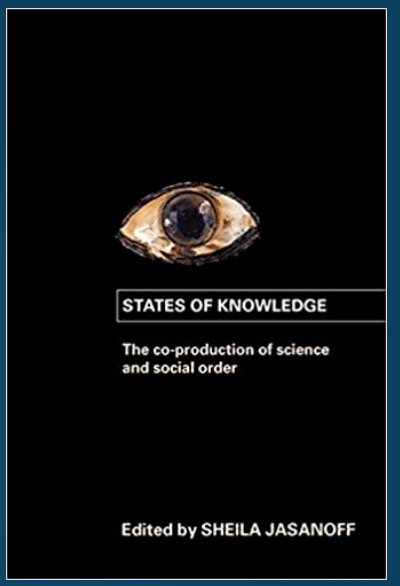
Lesson leant for the RRI perspective

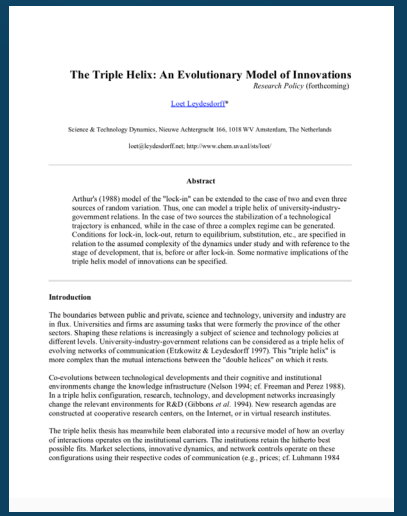
- rhetoric of progress and innovation and necessity of sharing problems (and not just solutions)
- understanding concerns of society and share uncertainties of science
- enhancing the “lay" local knowledge and experience
- re-framing and re-understanding science (and society)

(The need for) re-framing and re-understanding science (and society)

- Many models have been proposed regarding how science stays in society and how science works… even what science exactly is
- *Mode 2* production of knowledge
- *Post-normal science*
- *Co-production* of science and society
- *Hybridisation* of science and business



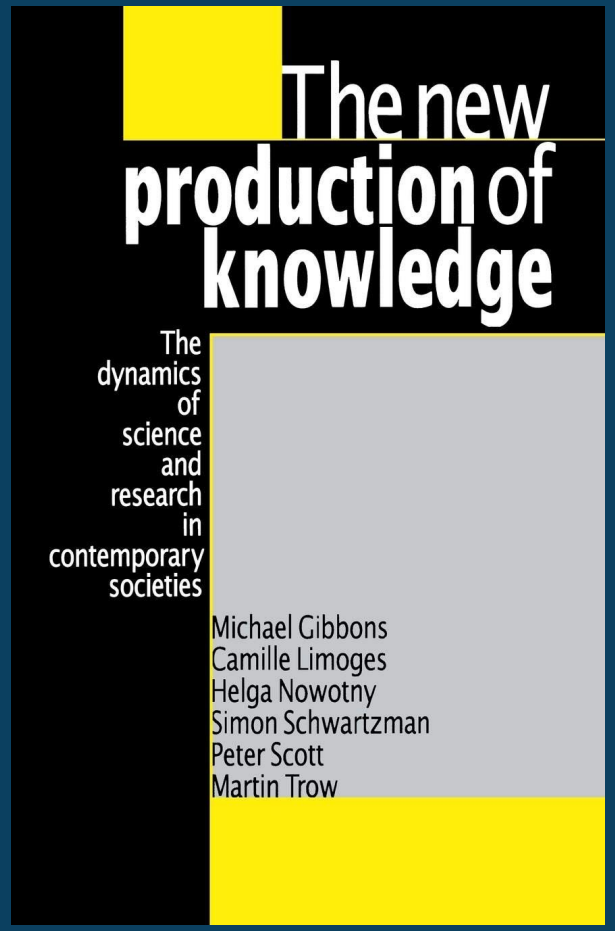




Re-framing and re-understanding science (and society)

- *Mode 2* production of knowledge

Changes in practice provide the empirical starting point of this enquiry. These changes appear in the natural and social sciences but also in the humanities. They can be described in terms of a number of attributes which when taken together have sufficient coherence to suggest the emergence of a new mode of knowledge production. Analytically the set of attributes is used to allow the differences between Mode 1 and Mode 2 to be specified with some clarity. To summarise using terms which will be explored more fully below; in Mode 1 problems are set and solved in a context governed by the, largely academic, interests of a specific community. By contrast, Mode 2 knowledge is carried out in a context of application. Mode 1 is disciplinary while Mode 2 is transdisciplinary. Mode 1 is characterised by homogeneity, Mode 2 by heterogeneity. Organisationally, Mode 1 is hierarchical and tends to preserve its form, while Mode 2 is more heterarchical and transient. Each employs a different type of quality control. In comparison with Mode 1, Mode 2 is more socially accountable and reflexive. It includes a wider, more temporary and heterogeneous set of practitioners, collaborating on a problem defined in a specific and localised context.



Gibbons, M. *et al.* (1994) *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London: SAGE.

Re-framing and re-understanding science (and society)

- *Post-normal science*

In response to the challenges of policy issues of risk and the environment, a new type of science—'post-normal'—is emerging. This is analysed in contrast to traditional problem-solving strategies, including core science, applied science, and professional consultancy. We use the two attributes of systems uncertainties and decision stakes to distinguish among these. Post-normal science is appropriate when either attribute is high; then the traditional methodologies are ineffective. In those circumstances, the quality assurance of scientific inputs to the policy process requires an 'extended peer community', consisting of all those with a stake in the dialogue on the issue. Post-normal science can provide a path to the democratization of science, and also a response to the current tendencies to post-modernity.

739

SCIENCE FOR THE POST-NORMAL AGE

Silvio O. Funtowicz and Jerome R. Ravetz

In response to the challenges of policy issues of risk and the environment, a new type of science—'post-normal'—is emerging. This is analysed in contrast to traditional problem-solving strategies, including core science, applied science, and professional consultancy. We use the two attributes of systems uncertainties and decision stakes to distinguish among these. Post-normal science is appropriate when either attribute is high; then the traditional methodologies are ineffective. In those circumstances, the quality assurance of scientific inputs to the policy process requires an 'extended peer community', consisting of all those with a stake in the dialogue on the issue. Post-normal science can provide a path to the democratization of science, and also a response to the current tendencies to post-modernity.

Science always evolves, responding to its leading challenges as they change through history. After centuries of triumph and optimism, science is now called on to remedy the pathologies of the global industrial system of which it forms the basis. Whereas science was previously understood as steadily advancing in the certainty of our knowledge and control of the natural world, now science is seen as coping with many uncertainties in policy issues of risk and the environment. In response, new styles of scientific activity are being developed. The reductionist, analytical worldview which divides systems into ever smaller elements, studied by ever more esoteric specialism, is being replaced by a systemic, synthetic and humanistic approach. The old dichotomies of facts and values, and of knowledge and ignorance, are being transcended. Natural systems are recognized as dynamic and complex; those involving interactions with humanity are 'emergent', including properties of reflection and contradiction. The science appropriate to this new condition will be based on the assumptions of unpredictability, incomplete control, and a plurality of legitimate perspectives.

At present, there is no agreed description of what the future will bring, but there is a general sense that much of our intellectual inheritance now lies firmly in the past. 'Post-modern' is widely used as a term for describing contemporary

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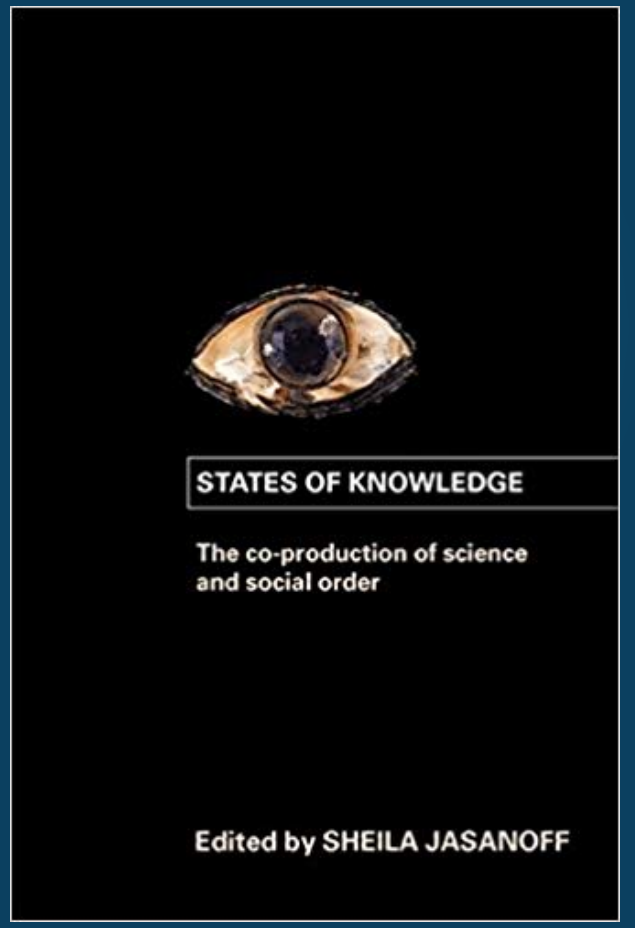
FUTURES September 1993 0016-3287/93/07739-17

Funtowicz, S. and Ravetz, J. (1993) 'Science for the post-normal age', *Futures*, 25(7), pp. 739–755.

Re-framing and re-understanding science (and society)

- *Co-production* of science and society

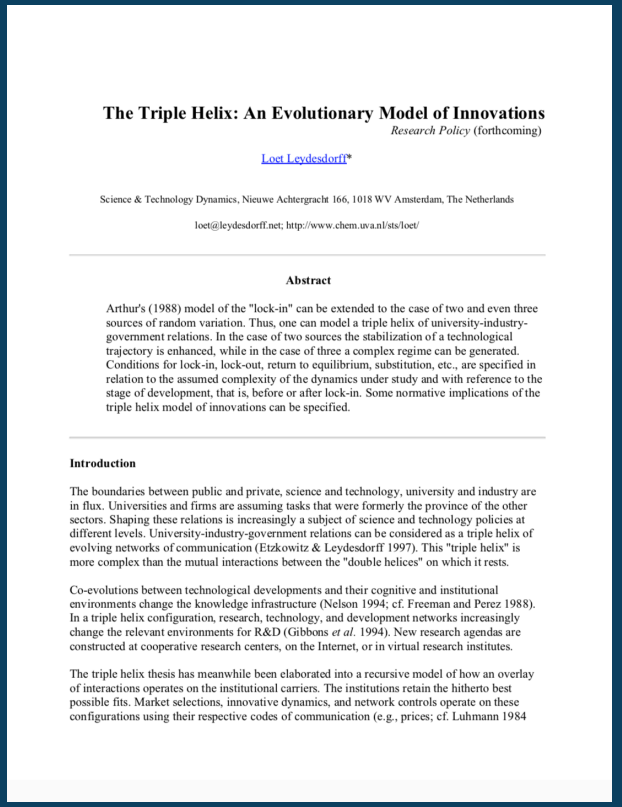
Briefly stated, co-production is shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it. Knowledge and its material embodiments are at once products of social work and constitutive forms of social life; society cannot function without knowledge any more than knowledge can exist without appropriate social supports. Scientific knowledge, in particular, is not a transcendent mirror of reality. It both embeds and is embedded in social practices, identities, norms, conventions, discourses, instruments and institutions — in short, in all the building blocks of what we term the social. The same can be said even more forcefully of technology.



Jasanoff, S. (2004) *States of Knowledge: The Co-Production of Science and the Social Order*. Routledge.

Re-framing and re-understanding science (and society)

- *Hybridisation* of science and business:
  - *Triple helix*
  - *asymmetric convergence*
  - *entrepreneurial university*
  - *third mission – knowledge transfer*
  - …



The Triple Helix: An Evolutionary Model of Innovations

Research Policy (forthcoming)

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Abstract

Arthur's (1988) model of the "lock-in" can be extended to the case of two and even three sources of random variation. Thus, one can model a triple helix of university-industry-government relations. In the case of two sources the stabilization of a technological trajectory is enhanced, while in the case of three a complex regime can be generated. Conditions for lock-in, lock-out, return to equilibrium, substitution, etc., are specified in relation to the assumed complexity of the dynamics under study and with reference to the stage of development, that is, before or after lock-in. Some normative implications of the triple helix model of innovations can be specified.

Introduction

The boundaries between public and private, science and technology, university and industry are in flux. Universities and firms are assuming tasks that were formerly the province of the other sectors. Shaping these relations is increasingly a subject of science and technology policies at different levels. University-industry-government relations can be considered as a triple helix of evolving networks of communication (Etzkowitz & Leydesdorff 1997). This "triple helix" is more complex than the mutual interactions between the "double helices" on which it rests.

Co-evolutions between technological developments and their cognitive and institutional environments change the knowledge infrastructure (Nelson 1994; cf. Freeman and Perez 1988). In a triple helix configuration, research, technology, and development networks increasingly change the relevant environments for R&D (Gibbons *et al*. 1994). New research agendas are constructed at cooperative research centers, on the Internet, or in virtual research institutes.

The triple helix thesis has meanwhile been elaborated into a recursive model of how an overlay of interactions operates on the institutional carriers. The institutions retain the hitherto best possible fits. Market selections, innovative dynamics, and network controls operate on these configurations using their respective codes of communication (e.g., prices; cf. Luhmann 1984

Leydesdorff, L. (2000) 'The triple helix: an evolutionary model of innovations', *Research Policy*, 29(2), pp. 243–255. doi: 10.1016/S0048-7333(99)00063-3.

Science, society, democracy

RRI IN THE PUBLIC ARENA

The near roots of RRI: EU research policy development

1941

Rome Treaties

1958

first drafts of common research policy

1974

FP1

1983

Maastricht Treaty

1993

European «knowledge society»

bologna process

European Research Area

2000

Innovation Union

2010

2014

2021

Big Labs «Age»

Framework Programmes «Age»

The near roots of RRI: EU research policy development

Rome Treaties

first drafts of common research policy

FP1

Maastricht Treaty

European «knowledge society»

bologna process

European Research Area

Innovation Union

1941 1958 1974 1983 1993 2000 2010 2014 2021

Big Labs «Age»

Framework Programmes «Age»

European Commission

Science and Society **Action Plan**

le of contents

European Science-Society interplay: objectives and rationales

2002

2007

Science and society

SCIENCE IN SOCIETY

Objective

To stimulate, with a view to building an open, effective and democratic European knowledge-based society, the harmonious integration of scientific and technological endeavour, and associated research policies in the European social web, by encouraging pan-European reflection and debate on science and technology and their relationship with the whole spectrum of society and culture.

Rationale

The influence of science and technology on our daily lives is becoming increasingly profound. Products of social activity and shaped by social and cultural factors, science and technology nevertheless remain a remote domain far from the daily concerns of a large part of the public and of policy decision makers, and continue to be the subject of misunderstandings. Contentious issues relating to emerging technologies should be addressed by society on the basis of well informed debate leading to sound choices and decisions.

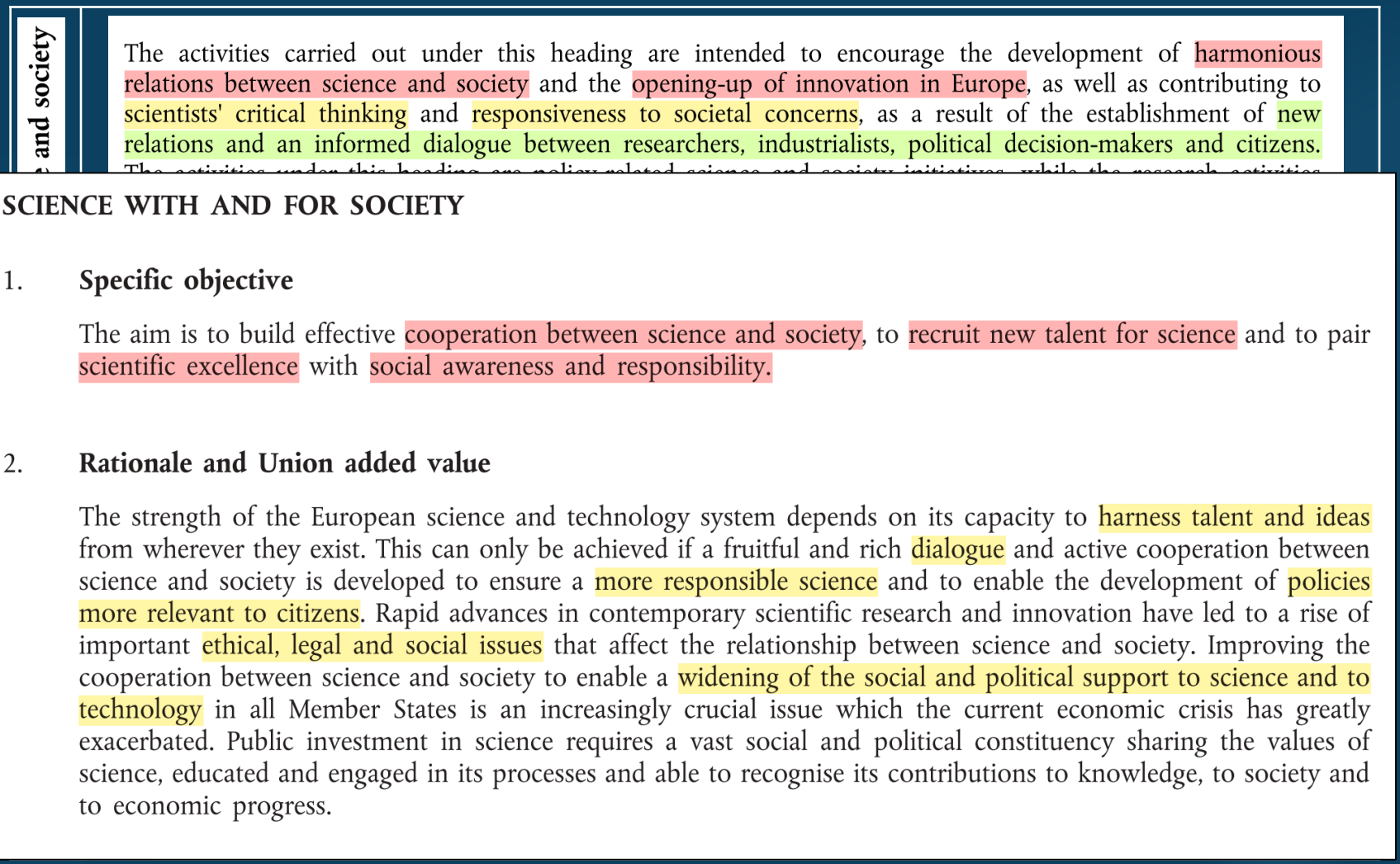
account the variety of views on them, which reflects European cultural diversity.

European Science *in* Society: public engagement as an instrument to co-produce science and innovation

*(**Increased public engagement**) is emphatically not about second-guessing the technical expertise of scientists and engineers. Rather, it is about acknowledging the fact that science and innovation are social, cultural and institutional – as well as technical and specialist – activities. As such, public engagement offers a way to be more accountable for the particular values and interests, which underpin both the governance of science and the general use of science in governance. What are the priorities and purposes, which justify the allocation of resources to different areas of innovation or lines of enquiry? What are the assumptions that inform the interpretation of scientific advice, concerning the behaviour of institutions or technologies in the real world? In short, public engagement is about the 'framing' of scientific evidence and technological projects, not about the details of specialist methods or technical analysis.* ***It is about being as rigorous and careful in validating the questions, as science itself is rightly respected for being in approaching the answers.***

Stirling, A. (2006). From Science and Society to Science in Society: towards a framework for "Co-operative research" - Report of a European Commission Workshop Governance and Scientific Advice Unit of DG RTD, Directorate General Research and Technology Development. Brussels.

European Science-Society interplay: objectives and rationales



and society

The activities carried out under this heading are intended to encourage the development of harmonious relations between science and society and the opening-up of innovation in Europe, as well as contributing to scientists' critical thinking and responsiveness to societal concerns, as a result of the establishment of new relations and an informed dialogue between researchers, industrialists, political decision-makers and citizens.

SCIENCE WITH AND FOR SOCIETY

1. **Specific objective**

The aim is to build effective cooperation between science and society, to recruit new talent for science and to pair scientific excellence with social awareness and responsibility.

2. **Rationale and Union added value**

The strength of the European science and technology system depends on its capacity to harness talent and ideas from wherever they exist. This can only be achieved if a fruitful and rich dialogue and active cooperation between science and society is developed to ensure a more responsible science and to enable the development of policies more relevant to citizens. Rapid advances in contemporary scientific research and innovation have led to a rise of important ethical, legal and social issues that affect the relationship between science and society. Improving the cooperation between science and society to enable a widening of the social and political support to science and to technology in all Member States is an increasingly crucial issue which the current economic crisis has greatly exacerbated. Public investment in science requires a vast social and political constituency sharing the values of science, educated and engaged in its processes and able to recognise its contributions to knowledge, to society and to economic progress.

2014

The ethical governance of emerging technology in Europe

- Biotechnologies: EC established experts groups to deal with «law-lag» in emergent techno-sciences
  - 1991: GAEIB (Group of Advisers on the Ethical Implications of Biotechnology) → 1997: EGE (European Group on Ethics in Science and New Technologies)

Whereas Community RTD activities must take ethical considerations into account;

Whereas there should also be technology assessment monitoring the possible risks, advantages and disadvantages of new technologies developed in this framework programme;

4th Framework Programme establishing act (1994)

(21) Whereas it is necessary to take into account the ethical aspects of advances in knowledge and technologies and their application and to conduct research activities in compliance with fundamental ethical principles and with the protection of privacy;

5th Framework Programme establishing act (1998)

Tallacchini, M. (2015) 'To Bind or Not To Bind? European ethics as soft law', in Hilgartner, S., Miller, C. A., and Hagendijk, R. (eds) *Science and Democracy. Making Knowledge and Making Power in the Biosciences and Beyond*. London: Routledge, pp. 156–175.

The ethica… emerging t… rope

- Biotechnologies… deal with «law-lag» in emergen…
  - 1991: GAEIB (C… ations of Biotechnology… hics in Science and New Technolo…

Ethical principles

1. All the research activities carried out under the Seventh Framework Programme shall be carried out in compliance with fundamental ethical principles.

2. The following fields of research shall not be financed under this Framework Programme:

— research activity aiming at human cloning for reproductive purposes,

— research activity intended to modify the genetic heritage of human beings which could make such changes heritable ([2]),

— research activities intended to create human embryos solely for the purpose of research or for the purpose of stem cell procurement, including by means of somatic cell nuclear transfer.

3. Research on human stem cells, both adult and embryonic, may be financed, depending both on the contents of the scientific proposal and the legal framework of the Member State(s) involved.

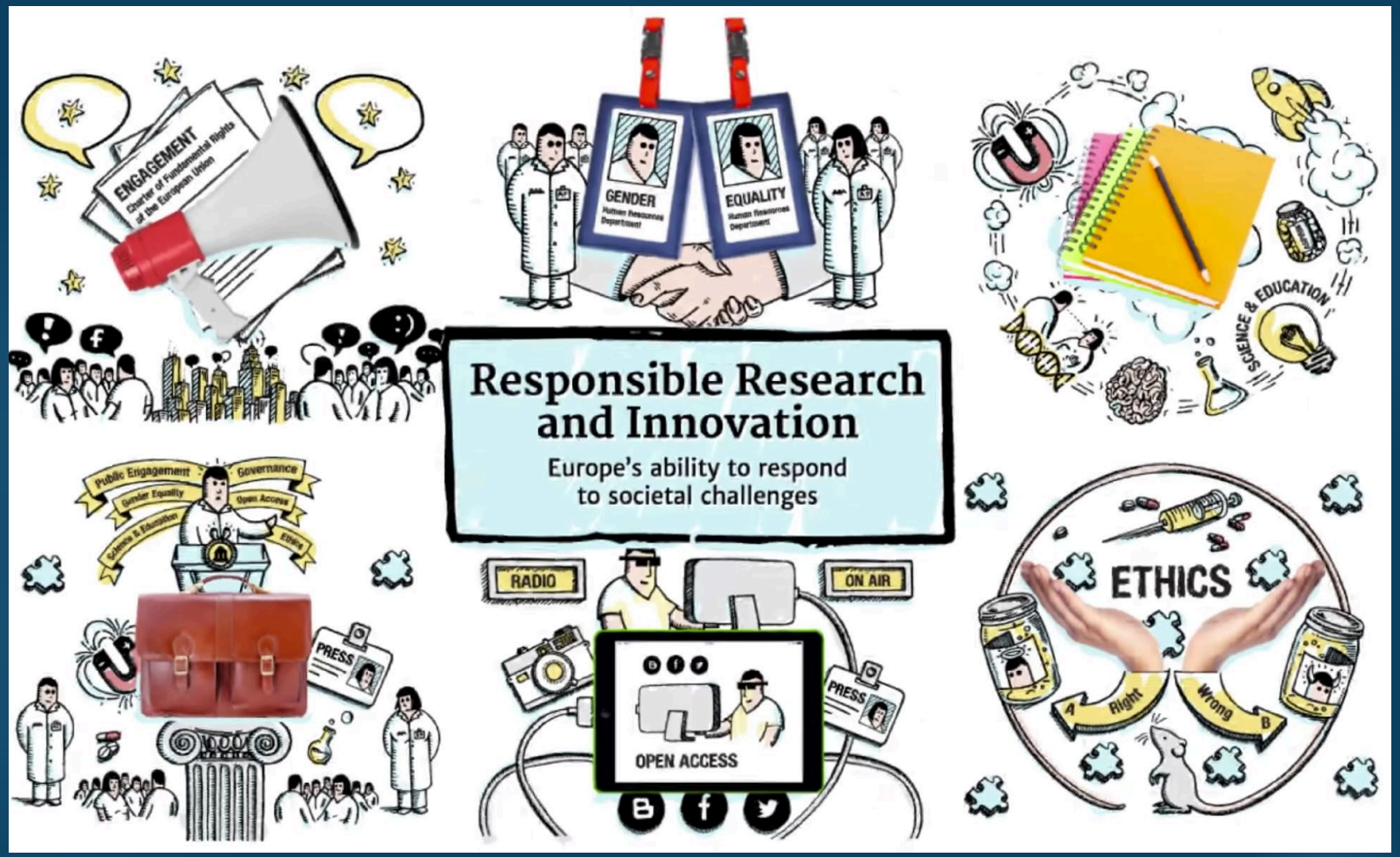
Any application for financing for research on human embryonic stem cells shall include, as appropriate, details of licensing and control measures that will be taken by the competent authorities of the Member States as well as details of the ethical approval(s) that will be provided.

As regards the derivation of human embryonic stem cells, institutions, organisations and researchers shall be subject to strict licensing and control in accordance with the legal framework of the Member State(s) involved.

7th Framework Programme establishing act (2006)

Tallacchini, M. (2015) 'To Bind o… S., Miller, C. A., and Hagendijk, R. (eds) *Science and Democracy*… *es and Beyond*. London: Routledge, pp. 156–175.

RRI – Responsible Research and Innovation



RRI key issues and process dimensions

HOW PUBLIC ENGAGEMENT, SCIENCE EDUCATION, ETHICS, OPEN ACCESS, GENDER, GOVERNANCE SHAPE RRI

RRI – focusing the concept

- A concept continuously under development!
- 2011: a reflection workshop on RRI and a report from Hilary Sutcliffe, plus a previous article by René von Schomberg.
  RRI is framed as including:
  - R&I to achieve a social benefit and the involvement of societal stakeholders;
  - prioritising social, ethical and environmental impacts and opportunities;
  - anticipating and managing risks to adapt quickly to changes;
  - openness and transparency becoming an integral component of the research and innovation process.
- 2012: paper by Richard Owen and Jack Stilgoe:
  - ask "what kind of future we want innovation to bring into the world";
  - emphasis on science **for** society, R&I targeted towards the major challenges and the 'right impacts', underpinned by a deliberative democracy;
  - emphasis on science **with** society, in which deliberation and reflection are coupled with action, which focuses on institutionalised responsiveness;
  - framing of responsibility in the context of research and innovation as collective activities with uncertain and unpredictable consequences, "challenging scientists, innovators, business partners, research funders and policy-makers to reflect on their own roles and responsibilities".


A report on Responsib
& Innovation

Hilary Sutcliffe, Director, MATTER

(On the basis of material provided by the Service
Prepared for DG Research and Innovation, European

Science and Public Policy **39** (2012) pp. 751–760 doi:10.1093/scipol/scs093

Responsible research and innovation: From science in society to science for society, with society

Richard Owen[1,*], Phil Macnaghten[2] and Jack Stilgoe[1]

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[2]*Department of Geography, Science Laboratories, Durham University, South Road, Durham, DH1 3LE, UK and Department of Science and Technology Policy, Institute of Geosciences, P.O. Box 6152, State University of Campinas, 13083-970, Campinas, SP, Brazil.*
[*]*Corresponding author. Email: r.j.owen@exeter.ac.uk.*

The term responsible (research and) innovation has gained increasing EU policy relevance in the last two years, in particular within the European Commission's Science in Society programme, in the context of the Horizon 2020 Strategy. We provide a brief historical overview of the concept, and identify three distinct features that are emerging from associated discourses. The first is an emphasis on the democratic governance of the purposes of research and innovation and their orientation towards the 'right impacts'. The second is responsiveness, emphasising the integration and institutionalisation of established approaches of anticipation, reflection and deliberation in and around research and innovation, influencing the direction of these and associated policy. The third concerns the framing of responsibility itself in the context of research and innovation as collective activities with uncertain and unpredictable consequences. Finally, we reflect on possible motivations for responsible innovation itself.

Keywords: responsible; research; innovation; science; policy.

1. Introduction: the emergence of responsible innovation in EU policy discourse

The terms 'responsible innovation' and 'responsible research and innovation' have a history stretching back a decade (Hellstrom 2003; Guston 2004; Owen et al. 2009a; Owen and Goldberg 2010; von Schomberg 2011a,b; Lee 2012; Armstrong et al. 2012), and even further if cognate terms such as 'responsible development' are included (National Nanotechnology Initiative (2007) and National Research Council (2006)[1] in the USA: see Fisher and Rip (in press) for further discussion). Indeed, these terms are heirs to even earlier discussions about research integrity and the ethical, legal and social implications of research in areas such as genomics. They also have roots in visions for collaborations between social, natural and physical scientists that address the wider dimensions of science and innovation early on (evident for example within the 5th and 6th EU Framework Programmes and their calls for socio-technical integration (Rodriguez et al, in press)) and calls for greater public engagement with science and technology (variations in which are analysed at an EU-wide level by Mejlgaard et al. (pp. 741–50, this issue)). Further roots include, but are not limited to, integrated approaches such as technology assessment in its various forms (Schot and Rip 1996; Guston and Sarewitz 2002) and anticipatory governance (Karinen and Guston 2010), some of which have been formalised within decision-making processes, such as the so-called 'Danish model' for technology assessment based on public participation and deliberation (e.g. through consensus conferences), (see Mejlgaard et al. pp. 741–50, this issue).

Over the last two years the concept of responsible research and innovation (RRI) has gained particular visibility and traction in an EU, and specifically European Commission (EC) policy context. Evolving from discourses of socio-technical integration within and beyond the EC Science in Society programme, RRI may also reflect recognition of the limitations of extant policy approaches to managing ethically-problematic areas of

source: RRI Tools

RRI – focusing the concept

- 2012: the European Commission disseminates another definition, where Responsible Research and Innovation
  - means that societal actors work together during the whole research and innovation process in order to better align both the process and its outcomes, with the values, needs and expectations of European society;
  - is an ambitious challenge for the creation of a Research and Innovation policy driven by the needs of society and engaging all societal actors via inclusive, participatory approaches;
  - is framed by six key issues: engagement, gender equality, science education, open access, ethics, and governance.
- 2013: René von Schomberg, "A vision of responsible innovation":
  "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."
- Stilgoe, Owen and Macnaghten, "Developing a framework for responsible innovation»: four dimensions of RRI:
  - anticipation in governance
  - reflexivity
  - inclusion of new voices
  - responsiveness in the innovation systems

source: RRI Tools

What is RRI about?

including all **actors**,

and considering specific **key issues** and **process dimensions**

source: RRI Tools

The process dimensions in depth

Diversity and Inclusion means **early involvement** of a wide range of of actors and publics in R&I practice, deliberation, and decision-making **to yield more useful and higher quality knowledge**. This strengthens democracy and broadens sources of expertise, disciplines and perspectives.

Anticipation and Reflection means to **envision impacts** and **reflect on the underlying assumptions**, values, and purposes **to better understand how R&I shapes the future**. This produces valuable insights and increases our capacity to act on what we know.

Openness and Transparency means **to communicate** in a balanced, meaningful way methods, results, conclusions, and implications **to enable public scrutiny and dialogue**. This benefits the visibility and understanding of R&I.

Responsiveness and Adaptive Change means to be able to **modify modes of thought and behaviour**, overarching organizational structures, **in response to changing circumstances**, knowledge, and perspectives. This aligns action with the needs expressed by stakeholders and publics.

source: RRI Tools

Questioning the process dimensions

Diversity and Inclusion

who are you involving (attention to and respect for differences) why (relevance of stakeholders) in which stages of the research process and how (engagement methodology) ?

Anticipation and Reflection

how do you address ethical, legal, social and/or environmental aspects? How do you assure envisioning plausible futures and facilitate deliberation on values, perceptions, needs and interests, now and in future?

Openness and Transparency

how did you tailor information and communication about processes, roles, actors, content and results (so as to be appropriate, honest and clear)?

Responsiveness and Adaptive Change

Were you able (flexible) to change practices in response to feedback, new circumstances, insights and values of stakeholders and the general public? How did you manage this?

source: RRI Tools

The six key issues

ETHICS
Ensuring research integrity, and science & society

GENDER EQUALITY
Promoting human resources in research for attaining gender balance

PUBLIC ENGAGEMENT
Fostering collaborative and multi-actor processes in R&I

SCIENCE EDUCATION
Increasing the knowledge and skills of citizens in order to promote scientific vocations and participation

OPEN ACCESS
Guaranteeing access to scientific knowledge to boost R&I

GOVERNANCE
Providing instruments to foster shared responsibility in R&I practices

source: RRI Tools

Ethics

European society is based on shared values. In order to adequately respond to societal challenges, research and innovation must respect fundamental rights and the highest ethical standards. Beyond the mandatory legal aspects, this aims to ensure increased societal relevance end acceptability of research and innovation outcomes.

RRI: Europe's ability to respond to societal challenges», European Commission 2012

Decisions in R&I must consider the principles on which the EU is founded, i.e. the respect of human dignity, freedom, democracy, equality, the rule of law and the respect of human rights, including the rights of persons belonging to minorities.

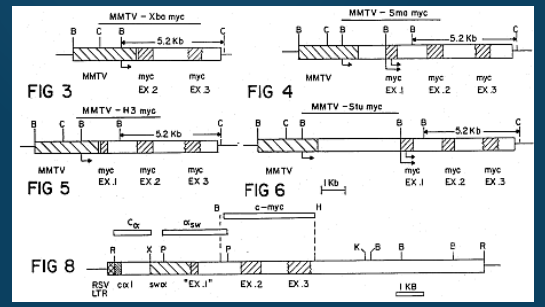
Rome Declaration, European Commission 2014

Ethics

- involvement of children, patients, vulnerable populations
- use of human embryonic stem cells
- privacy and data protection issues
- research on animals and non-human primates
- research integrity (no fabrication, falsification, plagiarism …)

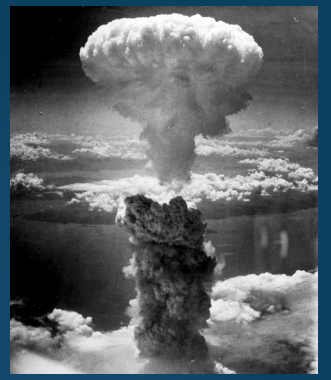
Questioning ethics

- How do you align your practices with the Code of Conduct for Research Integrity in the various phases, from research design to reporting results?
- Who will you involve in ethics-related reflection and decision-making for your R&I practices (patients families, customers, local organizations..) and how (channels)?
- How do you guarantee different values, interests and ideals?



Questioning ethics

- What are possible ethical considerations for your R&I practices? (ex: environmental, human and animal health, local economic and development impacts, social justice, education, data management …)
- How do you prevent potentially harmful impacts on the public or the environment?
- Do you consider the negative implications of your R&I practices?
- Who should be responsible for R&I impacts



Open Access

making research results freely available to anyone who wants to access and re-use them.
In RRI, openness should apply to all components of the research process, from its early beginning

Shift from OA to Open Science, (infrastructure, intellectual property rights, content-mining and alternative metrics, inter-disciplinary collaboration among all actors)

Questioning Open Access

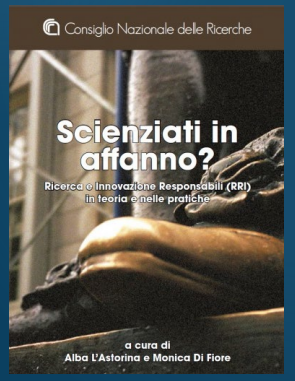
- Which parts of your work are open? (ex.; Objectives, aims and goals; Methodologies; Data; Preliminary / final results; Uncertainties and limitations)
- With whom do you share the results of your work?
- How are your communication activities made accessible to diverse stakeholders?

Gender

Il concetto di genere viene sviluppato negli anni 70 per studiare le relazioni, spesso asimmetriche, tra donne e uomini nella società. Mette in evidenza come molte delle differenze che caratterizzano l'esperienza di donne e uomini all'interno della società non sono naturali, ma sono socialmente costituite.

Il genere non è qualcosa che si è ma qualcosa che si fa. Spesso si pensa che genere sia una questione che riguarda le donne, ma in realtà esso riguarda piuttosto la relazione tra uomini e donne. Quando si vuole lavorare per cambiare le pratiche di genere, bisogna coinvolgere sia le donne che gli uomini

Barbara Poggio, Gender in Scienziati in affanno? 2018



Gender

Why is gender asymmetry a problem? The reasons why EC considers it important the gender issue in R&I

- ethical reasons: gender imbalances raise a problem of equity (equal rights);

- economic reasons: women do struggle to access scientific careers and decision-making positions in the world of research, but they are also excluded more easily and increasingly to progress of careers (leaky pipeline);

Gender

La terza dimensione che vorrei sottolineare riguarda la qualità della ricerca intesa in un'accezione molto ampia, che include aspetti come l'innovazione e la creatività. Varie ricerche hanno dimostrato che i contesti misti, dal punto di vista del genere, ma anche di altre dimensioni (età, cultura, ecc.) presentano livelli più elevati di creatività e innovazione in quanto portatori di prospettive ed esperienze diverse. Essi rappresentano meglio anche lo spettro della società, composta non solo da uomini, di una certa età, etnia o classe, ma da una pluralità di soggetti con caratteristiche differenziate.

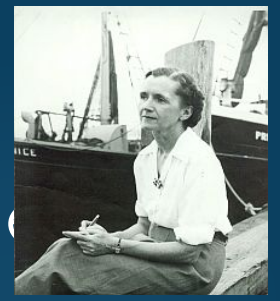
Barbara Poggio, *Gender* in *Scienziati in affanno?*, 2018

Gender

How does EU addresses gender issues?

In 2007, the EC changed its policy approach from "fixing the women" to "fixing the institutions" in line with the process related approach of gender mainstreaming. This includes both the provision of specific career support for women as well as institutional measures.

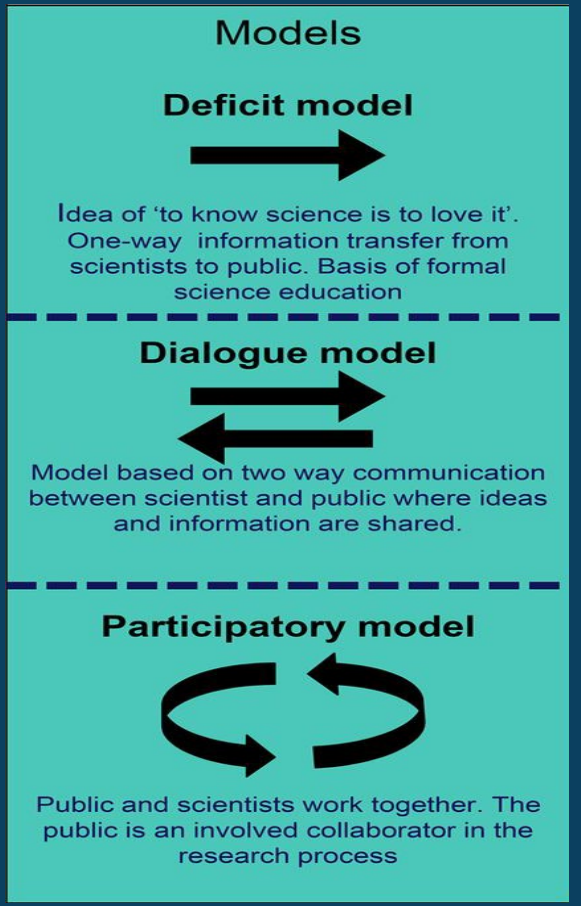
Questioning Gender



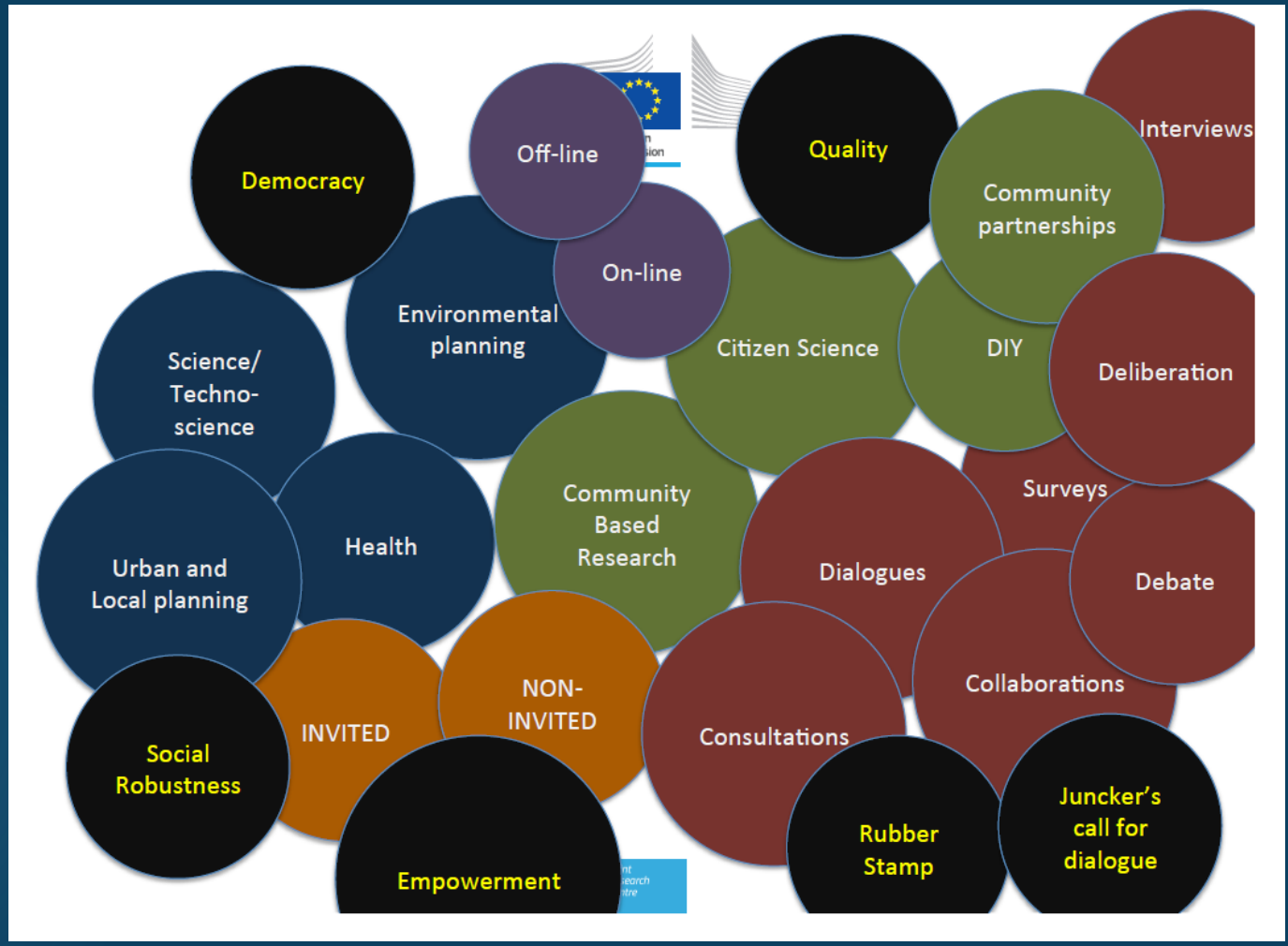
- How the research questions can impact (benefit/damage) women and men?
- What different gender implications could have th phases of the project (definition, implementation, monitoring and evaluation, dissemination)?
- Does your organization have a gender equality plan?
- What gender balance practices regarding staff and working conditions (ex. In teams, in management positions, in work spaces, in salary or contract conditions) do you consider?
- How do you address language issues?

Public Engagement

Public Engagement refers to the activities aimed at fostering the collaboration among all societal actors during the whole research and innovation process in order to "align its outcomes to the values, needs and expectations of European society".



Public Engagement: why and how?



Angela Guimarães Pereira, Public Engagement, in *Scienziati in affanno?*, 2018

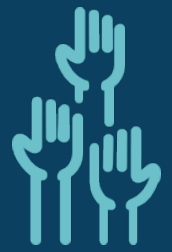
Public Engagement

per un efficace public engagement bisogna innanzitutto conoscere le persone che dobbiamo coinvolgere, capire le loro motivazioni, e scegliere il metodo adeguato per coinvolgerle. Se usiamo, ad esempio, gli strumenti online, limiteremo la partecipazione a coloro che accedono al web; se andiamo in un pub, avremo un altro tipo di partecipazione, di quelli che frequentano il pub.

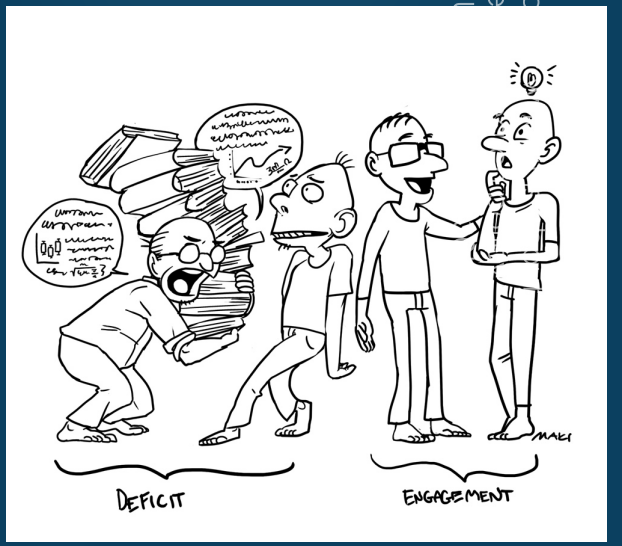
(...) se noi coinvolgiamo diversi tipi di persone nel dibattito pubblico, ciascuna con la propria conoscenza, esperienza, aspettative, immaginari, qualsiasi decisione in merito alle politiche pubbliche sarà più ricca e avrà maggiore qualità

Angela Guimarães Pereira, Public Engagement, in *Scienziati in affanno?*, 2018

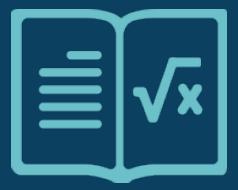
Questioning Public Engagement



- How do you involve stakeholders / public in your work (channel, stage, language) and why ?
- What dimensions will you discuss during your engagement activities (Values, needs and perceptions important to stakeholders; Framing of R&I questions; R&I methodologies; Possible impacts (ethical, legal, economic, environmental, social; Role responsibilities; Potential improvements to the R&I process)
- How do you address critical aspects of public engagement activities?



Science Education

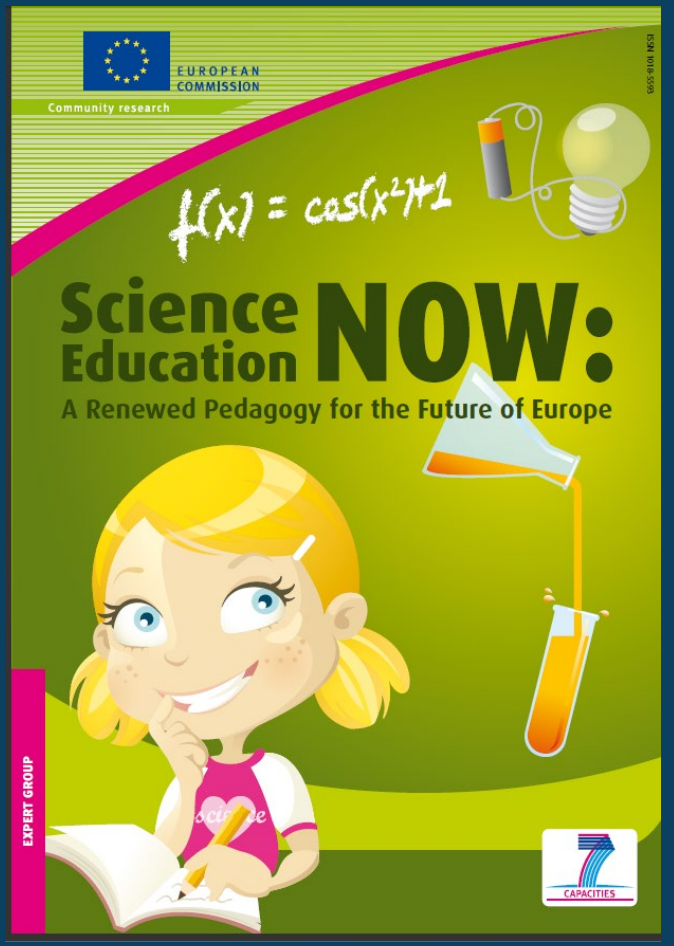


Science Education aims at 1) enhancing the current education process to better equip citizens with the necessary knowledge and skills that allow them participate in the debate; and 2) to motivate students towards scientific careers.

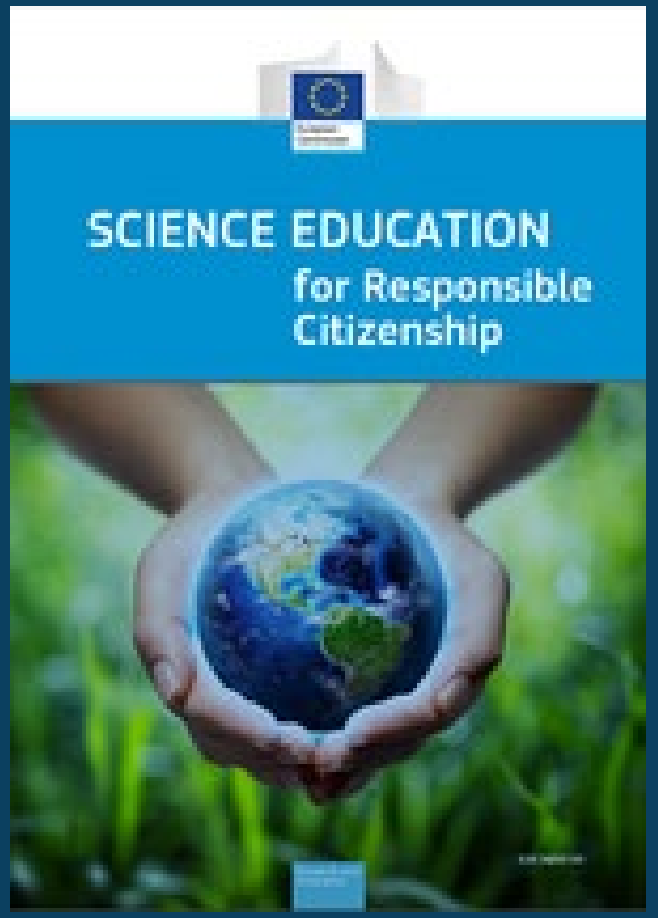
In EC there has been a shift from linear model of cultural deficit towards a more interactive vision of learning affirming the centrality of the learner, never a *tabula rasa* but bringing tacit knowledge, motivations, passions, opinions and different needs.

Science Education

EC 2004



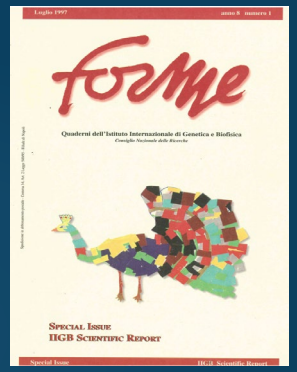
EC 2007



EC 2015

Questioning Science Education

- How do you provide tailored information and education resources to specific stakeholder groups (ex.: which media; how you address different languages of target groups; which channels or events)?
- Which stakeholders are taking part in your education activities, and why?
- Do you use innovative education tools?
- How do you promote reflection on R&I's impacts (ethical, legal, economic, environmental, social) in your science education activities?

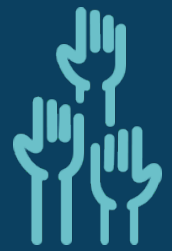
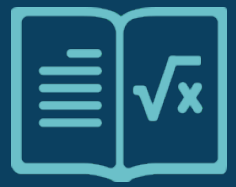


Governance

Governance, more than a key dimension of RRI, is considered as a "horizontal dimension" affecting all the other ones as it has to do with how knowledge is produced and how it is disseminated.

From *governing* (hierarchical, top-down approach) to *governance* (horizontal, interactive, networked process of political management)



Questioning Governance

- Who is involved in setting your R&I agenda (Management or advisory boards; Funding organisations; Stakeholders; Other teams and colleagues; Members of the public)?
- How are views from other research or societal groups included in your R&I practice?
- What organisational changes are needed (ex.: Modifying science governance system so it responds to public demands; Creating/implementing structures that enable engagement; Setting up incentive systems to encourage changes; Making accountability and transparency are the bedrock of every stage; Practising open science …) to adapt your R&I processes to stakeholders' input?

Finally, RRI is a matter of asking the good questions

The kind of questions that public typically ask scientists, or would like to see scientists ask of themselves …

Which values should lead innovation in Europe?
What are the right impacts that innovation should be directed towards and how should these be arrived at?
Why doing innovation? For what purpose? Are their goals desirable?
Who could benefit and how? Who remains excluded?

(Stilgoe, Owen, and Macnaghten 2013)

What sort of future do we collectively want

(Owen 2011)