> Perspectives on Biotechnology Communication

Controversies - Contexts - Formats

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> CONTENTS

SUMMARY

Biotechnology, and genetic engineering in particular, have been a point of focus for public debate in Germany for almost 40 years. However, controversy in social and academic settings centres around specific application rather than on the theory of biotechnology itself. Conceptualizing this public controversy as a lack of acceptance that can be overcome by providing greater information misses the point. Controversy is by nature important, and should not be swept under the carpet by communications. When it comes to new technologies, dialogue between scientists and the public at large is vital.

"Biotechnology" is not "biotechnology"

Nowadays, biotechnology is a key enabling technology. It is used to develop new medicines, breed new plants and crops and produce everyday products such as washing powder and cosmetics more efficiently. The German Federal government estimates that the value of global industrial biotechnology sales will rise from €50 billion today to around €300 billion in ten years' time. Compared with other key enabling technologies such as microelectronics, the public ask particularly penetrating questions about biotechnology. Nevertheless, society's view of the various sectors and applications of biotechnology is quite differentiated.

In Germany, agricultural products that are developed by green genetic engineering in particular meet with strong resistance. The debate focuses on moral aspects, such as man's position in his environment, as well as consumer protection, health issues and the environmental impact. Red genetic engineering and its medical applications, however, meet with broad acceptance. The benefits of these applications for consumers are plain to see. White genetic engineering – the use of biotechnology in the manufacturing of industrial products – is also seen as unproblematic, since its effect is limited to a closed system such as the factory. Opinions on synthetic biology and nano biotechnology differ, however, and these are viewed with broad scepticism. It has obviously not yet been possible to eliminate the controversy surrounding biotechnology simply by improving communications on research and science. Each side of the debate seems to be at loggerheads, and a general rejection of green genetic engineering has been established.

Take criticism and fear seriously

This has less to do with a lack of information than it does with the fact that people do not perceive consumer benefit, but instead just see personal risk. Communication cannot overcome these doubts, since they are based on fundamental fears and attitudes in the population – and these are notably constant. As a result, information that does not correspond to people's own attitudes is ignored or misunderstood, perhaps because the communication rejects perceived risks as being irrelevant. The marketing of science to try to sell the advantages and security of biotechnology is therefore doomed to failure. If, in contrast, public critique is taken seriously, the objective of communications cannot be to achieve a predefined opinion. Rather, the aim should be to create socially robust knowledge. Existing fundamental beliefs and everyday preconceptions remain the key context for scientific communications, and must be taken into account.

Dialogue is vital

Previously, scientists assumed that people simply had to be given a sufficient level of information for their new technologies to be popularly accepted. In this „deficit model", researchers provide an ignorant society with facts in a way that is allegedly understandable. For over ten years, however, conversational models have become increasingly important in the communication of scientific and technical concepts. "Dialogue" entails bidirectional understanding. In this way, not only does the public learn from science, but science also hears its opinions, expectations and fears. Serious dialogue must offer a choice of paths, and be open to the results. This form of science communication should be initiated at the latest when the first applications become apparent. While insufficient on its own, dialogue is thus a necessary condition for the acceptance of biotechnology.

A range of formats can be used for bidirectional communication and to involve citizens in dialogue. Web 2.0 channels are also viewed as promising. Scientists must engage through these interactive areas of the web and other social networks to provide evidence-based information to help consumers form their own opinions and to share ideas with the general public. If they do not do this, other campaign groups will possibly take their place.

acatech gives the following recommendations:

> RECOMMENDATIONS TO SCIENCE AND INDUSTRY

The first of these recommendations is essentially applicable to all scientific communication situations. Thus, acatech recommends that information sources and communication objectives are as transparent as possible, and that research, methods of estimating risk and opportunities and procedures for political regulation are included within the communication (recommendations **1 to 3**).

(4) *acatech recommends* that scientists who, as communicators, already invest significant resources in terms of funds and time, strive to increase their visibility and maintain credibility in the eyes of generally less specialised but in media terms more strongly represented opinion formers.

(5) *acatech recommends*, for the purpose of targeting specific groups, the adoption of a more problem-oriented approach to communication with the general public rather than a technology-oriented approach.

> RECOMMENDATIONS TO SCIENCE, INDUSTRY AND POLITICS

(6) *acatech recommends* that the positions and value judgements held by individual stakeholders, including those outside the scientific community, be treated with respect throughout all communication processes, and to be given due, serious consideration, without prejudice. In relation to the dialogue between science and society, options need to be investigated for ensuring that information and opinions are gathered and received systematically from the general public by science and industry.

(7) *acatech recommends* that a web-based clearing house be created to gather and disseminate information on controversial topics from all interest groups in a balanced way.

(8) *acatech recommends* that in addition to the proven models of communication and participation, new, innovative forms, in particular in relation to the new media (Web 2.0), be further tested, developedand evaluated.

> RECOMMENDATIONS TO HIGHER EDUCATION

(9) *acatech recommends* that training in basic skills for science communication (for specific target groups and based on facts) be integrated into higher education.

> RECOMMENDATIONS TO SCIENCE STUDIES

(10) *acatech recommends* that science studies be launched to systematically bring together the findings of theoretical research with practical experience.

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> PROJECT PROCESS

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In the course of this project, experts were asked to investigate three principle areas: controversy in or concerning biotechnology, social science research into biotechnology and examples of science communication on biotechnology.

The experts comprised:

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The specialists' expertise was discussed by invited panels of experts at two workshops held in March and October 2011. This acatech POSITION PAPER was prepared on the basis of the material that was gathered and further enquiry, after which the project group derived the recommendations. The draft project report and recommendations were discussed and validated with representatives from industry, the media and agencies for communication.

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PREAMBEL

Successful dialogue between science and the general public is a vital prerequisite for the development and introduction of new technologies. For acatech, therefore, the shape of technology communication and various communication formats occupy a large area of focus.

Science communication cannot simply be concerned with generating acceptance of specific technologies. Rather, the National Academy of Science and Engineering sees its role in shaping the use of existing and development of new technologies as part of a comprehensive process of developing consensus on scientific requirements, interests, values and preferences, taking into account all interested groups in society, as far as is possible according to the scientific and technical opportunities available.

An openness to technology among dialogue partners is a prerequisite for this.

In this project, experiences from controversies and communication measures concerning green genetic engineering and other fields of biotechnology have been analysed from the perspective of communications theory and social science, and from a historical viewpoint. The analysis has been used to derive recommendations on how to biotechnology issues should be communicated appropriately in the future, with balance and the objective of allowing the other party to reach a judgement. The recommendations may be transferable to other areas of scientific communication. They are addressed at those in science and industry who are concerned with providing and communicating information, as well as at politicians who are well placed to promote new communication processes.

1 INTRODUCTION

Biotechnology - yesterday, today and tomorrow

Biotechnology, or the application of science and technology to living organisms, is a prime example of the „new technologies" that define the extent of opportunities currently available to our modern society. In the 19th century, the microscope and biochemistry led to the discovery that microorganisms are responsible for alcoholic fermentation and a range of other chemical reactions. New applications of biotechnology became apparent in the field of medicine in the 20th century. However, it was only when we established the gene as the central reference point[1] that targeted control and exploitation in the form of a true bio-technology became tangible.

Biotechnology as we now understand it took significant impetus from genetic engineering, that is, from the methods and processes for isolation, research, modification and transfer of genetic material. Genetic engineering not only provided considerable emphasis for the development of biotechnology, but now also forms the focus of fierce public debate and controversy. In contrast to other key enabling technologies[2] such as microelectronics and nanoelectronics or photonics, the population at large have been asking particularly urgent questions about biotechnology for a number of decades. Significant resources have been deployed (in Germany as well as in other countries, such as Great Britain), to reassure the population about green genetic engineering - so far without great success: On average, with a small majority, 54 percent of Europeans believe that genetically modified (GM) food is not good for them or their families. For Germany that figure rises to 69 percent.[3]

Nowadays, biotechnology is a key enabling technology. It is used to develop new medicines, breed new plants and crops and produce everyday products such as washing powder and cosmetics much more efficiently. According to estimates, the value of global industrial biotechnology sales will rise from €50 billion today to around €300 billion in ten years' time.[4] It is thought that by 2030, biomaterials and bioenergy will comprise one third of total industrial production.

Biotechnology communication

For decades, there has been social scientific research into biotechnology in relation to science, industry, the media, politics and the general public.[5] Overviews of the forms of scientific communications have been created[6] and individual formats have been investigated.[7] The population is regularly canvassed for its views on biotechnology, for example at European level.[8] Such surveys and analysis lead us to make specific statements that relate to the role of the media, for example.[9]

The degree of agreement with a technology – according to the findings of numerous studies – does not depend on how well informed the participants are. Furthermore, the area in which genetic engineering methods are being used can drastically change the attitudes of the population to the methods themselves. Therefore, it is not adequate to talk about a general and undifferentiated hostility to genetic engineering.[10]

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1 e.g. Keller 2001.
2 Cf. e.g. European Commission 2011.
3 European Commission 2010, p. 20 et seq.
4 Federal Government 2012.
5 The following work in which the members of this project group were directly involved comprise: van den Daele/Pühler et al. 1996; Hampel/Renn 2001. Further bibliography added by Hampel 2012 and Bonfadelli 2012.
6 e.g. von Aretin/Wess 2005; Weingart et al. 2007.
7 e.g. acatech 2011.
8 e.g. European Commission 2010.
9 e.g. Bubela et al. 2009, p. 514 - 518.
10 Cf. acatech 2011b on technology acceptance in general.

A lack of openness to technology in some areas may at first glance lead to a consideration that communications activities should be expanded to include a sort of marketing. All experience and analysis of communication on biotechnology and other new technologies indicates, however, that such approaches are then doomed to failure if the initial rejection is founded on deep-rooted fears and concerns, or base values. In contrast, if the criticism from society is taken seriously, new doors can be opened for a dialogue more in tune with the time. The objective of such communications can obviously not be to impose a predefined opinion, but instead to create a socially robust knowledge. In fact, it can be argued that socially robust knowledge is better than the „reliably informed knowledge" that comes solely from an academic background. First, socially robust knowledge has a strongly empirical dimension and is constantly tested and refined in a process that is both open and open-ended. Secondly, it is infiltrated and improved by the knowledge of society. Finally, there is a methodological improvement that is derived from a more comprehensive spectrum of views and techniques.[11]

In the past, a variety of approaches have already been made to redefine communication on biotechnology in general and in relation to green genetic engineering in particular: For example, the participants have been asked to „acknowledge and accept that the discussion and assessment of the presented arguments should take place according to a principle of authenticity" instead of simply conducting a „head-on clash" in an „argument based on a spirit of mistrust and manipulation of opinion".[12] An international interdisciplinary group of experts has underlined the following particular expects in relation to scientific communications in the field of biotechnology: Early integration of the general public, suitable „framing" of the content, reflection on the role of the media.[13]

Preview

This acatech POSITION paper first introduces the topic by considering themes and controversies from the field of biotechnology. It reveals a high level of differentiation and demonstrates a range of different methods and perspectives on controversies.

Then, a context is defined for biotechnology communication, in which the specific activities of communication and participation occur that will subsequently form the discussion in a variety of formats and between a variety of actors.

In the conclusion, we then draw recommendations for the aforementioned target groups on the basis of these discussions.

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11 Nowotny et al. 2001.
12 Gottwald 2010.
13 Bubela et al. 2009, S. 517.

2 BIOTECHNOLOGY CONTROVERSIES

Controversy extends far beyond the purely experimental confirmation or rebuttal of a given hypothesis. This is true not only for discourse within science, but also of scientific controversies that are conducted in and with the public. In a controversy, the assumptions and arguments of all parties are examined in microscopic detail by their opponents. Controversy can be seen as a key to science, in three different ways.[14] First from a methodological perspective, since controversy is indispensable for scientists, for the process of generating scientific findings. Second from a didactic perspective, since it provides a key to understanding of the science for young people, students and other interested parties. And third from a political perspective, since it provides society with a channel to discuss scientific topics. In the case of public controversy, the interaction between science and society is tangible. Actually, controversies that characterise the methods of the natural sciences and the discursive energy of science itself. Only these can allow scientific theories to be developed. The argument around the correct position is necessary and productive. The image of the natural sciences „quarrelling“ and being „implausible“ is, therefore, inappropriate.

The fields of application in biotechnology are typically divided up into colours. In particular, green (plant) biotechnology and red (medical) biotechnology have been at the focus of controversy in the scope of the debate on genetic engineering.

2.1 CONTROVERSY AROUND GENETIC ENGINEERING IN GERMANY

There has been controversy on genetic engineering from the start.[15] No sooner was the genetic code successfully cracked in the 1960s, than the question arose „Will society be prepared?“[16] In 1973, when Herbert Boyer reported to the Gordon Research Conference on Nucleic Acids in New Hampton (New Hampshire) on the transfer of foreign DNA to bacteria, he elicited intense discussion of the potential risks of the new technology among experts. A milestone in the internal scientific debate was reached at the meeting at the Asilomar Conference Center in Pacific Grove (California) in 1975. As a result of this meeting, the National Institute of Health formulated guidelines on the handling of recombinant DNA, with the aim of preventing the accidental release of hazardous organisms. To a certain extent, in the first few years the researchers themselves pointed to the potential risks in their work and demanded rules.

In Germany, in 1978 the „Guidelines on protection against risks from in-vitro recombinant nucleic acids“ were adopted on the basis of the US model. Until the early 1980s, the debate on genetic engineering in the Federal Republic of Germany, as in the USA, was fixed on questions of safety. The principle actors were the scientists working in the field.[17]

However, with the first commercial applications of genetic engineering, the debate expanded to include economic and innovation policy aspects. German politicians were especially concerned with making up for the obvious head start that had been made in the USA. In 1984, the first genetically manufactured pharmaceutical (insulin) reached the West German market, and the first production facilities for this area were commissioned. The new technology became increasingly real.

Around this time, the topic started to appear in the media to an appreciably greater extent, although some

14 Weitze/Liebert 2006.
15 Cf. Wieland 2012.
16 Nirenberg 1967.
17 Jasanoff 2005.

publications had already broached the subject before.[18] Moreover, the debate, which by now had reached the general public in the Federal Republic of Germany, expanded from risks and opportunities to include ethical, legal and social aspects.

From 1984 to 1987, the Federal Parliament's Committee of Inquiry „The opportunities and risks of genetic technology" made the expansive field accessible to the political classes, and available to parliament.[19] From then on, the different fields of application of biotechnology were considered separately. While the Committee first hoped to achieve the broadest possible consensus, the Green party tabled a dissenting opinion. This dissenting vision considered the development of science and technology in industrialised countries to be misguided and culminated in the recommendation to „cease all applications of genetic engineering" and enable public debate on the „ethical principles, objectives and usefulness, of the social and ecological compatibility of biomedical research" and its applications.[20]

Transgenic products first landed on the dining tables of consumers in Europe towards the end of 1996, when genetically modified soya beans were imported from the USA. However, people were largely left in the dark about this.[21] Greenpeace quickly became the leading voice in the fight against what was known as „GM food". Calls for boycotts and swoops on supermarkets to find GM produce were among the media stunts that were intended to sensitise the public to the issue and that demanded labelling requirements.

Figure 1: Spiegel cover 10/1997 „Der Sündenfall"

Source: SPIEGEL-Verlag Rudolf Augstein GmbH & Co. KG.

At the same time, the cloning of Dolly the sheep from adult somatic cells at the beginning of 1997 once again brought up the question of where to set the limits on genetic techniques and reproduction, to avoid horrors such as the cloning of people (figure 1).

18 For example, Rainer Flöhl, who repeatedly spoke for genetic engineering in the Frankfurter Allgemeine Zeitung and also reflected on the progression of the debate: Thus in 1979 he expressed his disconcertment about the sea change in argumentation by leading molecular biologists, who just a few years before had still referred to the potential risks of genetic engineering yet now attempted to portray the new technology as fully harmless. The link between this transformation in opinion and the commercial activities of his protagonists appeared all too obvious. (Brodde 1992, p. 168; after Wieland 2012).

19 German Lower House of Parliament 1987.

20 German Lower House of Parliament 1987, p. 315 - 357.

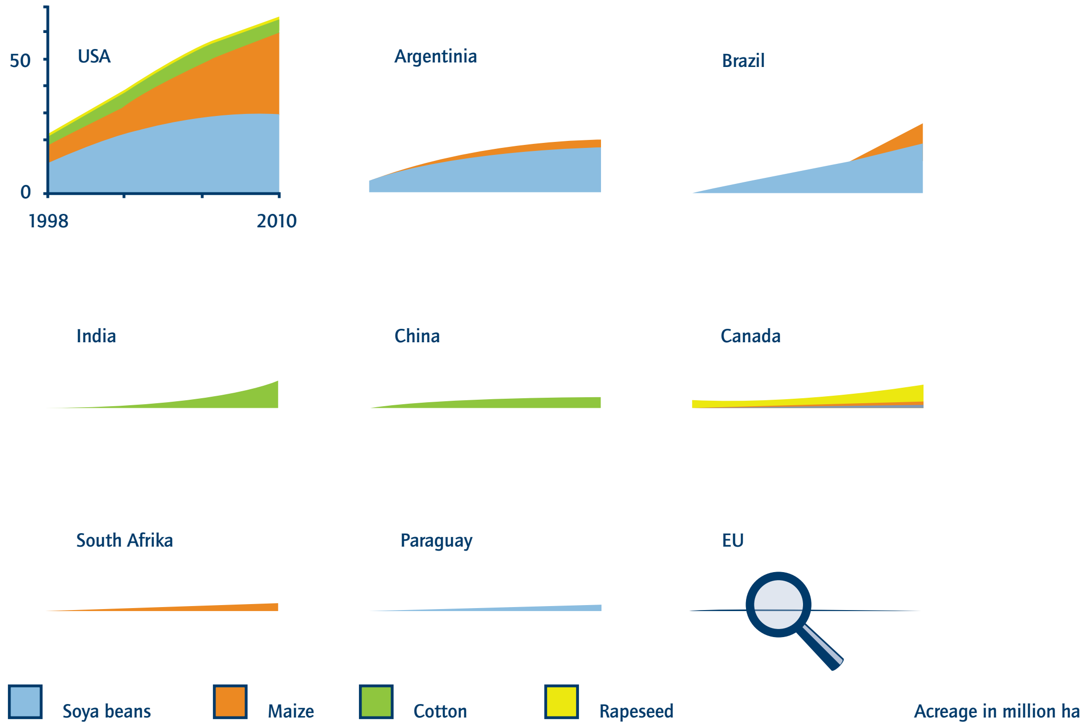
21 Wieland 2012.

Today, numerous applications of genetic engineering are part of normal life – from the GM (genetically modified) manufacturing of enzymes for detergents through genetic engineering production processes in the pharmaceuticals industry to genetic fingerprinting for the purpose of crime detection and gene-based paternity testing. The next section looks at the public debates on the various fields of biotechnology and traces the change in public opinion over time.

2.2 GREEN GENETIC ENGINEERING

Green genetic engineering and its associated products are at the core of the public debate and are considered to be broadly unacceptable in Germany. Globally, green genetic engineering can be described as a growth market.[22] Genetically modified plants are cultivated, however, primarily in countries in North and South America (figure 2).

Figure 2: Acreage for genetically modified plants in different countries



Source: pigurdesign/www.transgen.de.

22 After Boysen 2012.

In Germany, the tendency against green genetic engineering is high. Nevertheless, the debate has many aspects. The controversies associated with green genetic engineering comprise fundamental aspects – questions of economy, risk, the moral supremacy of nature and Christian creationist concepts as well as of the position of humans in their environment – plus aspects of consumer protection, associated with the environmental impact and effects on health. Consider first the **fundamental controversies**.

- Output traits (the characteristics of genetically modified plants that relate to usage properties after harvesting, in particular an optimisation of protein structure and other constituent substances) are currently largely still being researched. Ideas range from optimised protein structure, via health foods to bio fuels. The **lack of recognisable benefit** to consumers, especially in Central Europe, is seen as a significant reason for a rejection of green genetic engineering. So far there are no commercial GM varieties of either wheat or rice – i.e. alongside maize the world's most important crops for use in food production. „Golden rice", which is enriched with provitamin A and is intended for use in countering malnutrition above all in emerging nations, is held up by proponents as an up-and-coming example for the suitable use of GM crops in food.[23] When this new variety is introduced and how successful it will be remains to be seen. Critics suspect that the highly anticipated introduction of Golden Rice will be used to reduce the level of risk associated with GM crops in general.[24]
- The commercialisation of green genetic engineering is currently focusing on the input traits of crops (i.e. characteristics that increase or stabilise crop yields in the field), in particular tolerance to herbicide and pest resistance. Both characteristics are significant, since on the one hand (according to the proponents) they allow greater yields to be obtained at lower costs, and on the other hand (according to critics) they represent further „industrialisation" of agriculture. The critics actually question whether the fight against pests and weeds using GM herbicide-tolerant and pest-resistant varieties is sustainable. A large-scale cultivation of crops with the same herbicide tolerance would, they say, favour the emergence of resistances against this herbicide. In addition, successfully combatting primary pests could simply allow other pests to dominate the arena.[25] With these arguments, the criticism is directed less at green genetic engineering and more at the **direction being taken by agriculture.** Obviously one could also argue that the benefits of organic farming, in the sense of a large-scale rejection of artificial fertilisers and pesticide, could be combined with the benefits of higher yields from conventional farming: „With the transfer of genes to crops, fruit and vegetables for the purpose of disease and pest resistance, we now have transgenic plants available that demonstrate integrated crop protection without harming the environment. We can therefore speak of a form of ‚organic genetic engineering'. This means that we are able to combine sustainable crop cultivation with high yields."[26]
- Among the criticisms levelled at the direction that agriculture has been encouraged to take because of green genetic engineering, is that in particular the „agricultural corporations" that combine agricultural chemistry with seed development profit from green genetic engineering while farmers and consumers see scarcely any benefit but bear all of the risks.[27] In addition, the critics say, the farmers' dependency increases since herbicide-tolerant seed is associated with the complementary herbicide.[28]

23 http://www.goldenrice.org.
24 e.g. Then 2012, S. 22 et seq.
25 Resistances can naturally also occur in conventional agriculture.
26 Kempken 2009, S. 26.
27 This ad hoc evaluation does not compare to a differentiated analysis, however, cf. Boysen 2012.
28 A differentiation must also be made here, for example according to the status of patent protection of the herbicide, e.g. Brookes/Barfoot 2009.

The problem outlined here, therefore, is that of an unequal **distribution of the cost-benefit ratio between the big and the small.**

- Both proponents and critics of green genetic engineering proclaim **food safety** as part of their approach. Proponents refer to the increases in yield made possible by GM crops. Critics declaim the destruction of locally adapted small-scale farming structures.
- The „value of creature" – in the sense of the „**intrinsic value" of a living organism** – can also be applied to plants.[29] A transgression would then be caused by the introduction of foreign genetic material, although even traditional breeding techniques and techniques such as somatic fusion, mutation breeding and polyploidy breeding may cause serious interventions and cross-species connections. The introduction of foreign genes is also relevant for the assessment of what is considered **natural or artificial** in the realm of crops and food. In public debate, the „natural" is often seen as the higher quality, correct and appropriate variant. If the differentiating characteristic between natural and artificial is to be the use of foreign-species genetic information, then cis-genic plants (plants that have had same-species DNA transferred to them, in contrast to trans-genic plants, which have had foreign-species DNA transferred) would be defined as more „natural". The same would apply to precision breeding products, for which genetic engineering techniques are used to perform genetic analysis, but into which no foreign gene material is transferred.

In view of the manifold and in public perception increasingly frequent „food scandals", the public's confidence in the responsible authorities is low overall.[30] Against this backdrop, the following controversies exist in respect of the **environment, health and consumer protection:**

- With the current transfer techniques for modification of the nuclear genome, the transferred DNA is integrated into the crop DNA at a random location. In some circumstances, this impairs the gene regulation of cells. Critics consider the **high intensity** of the intervention to represent a particular risk. Proponents refer to the fact that in the scope of mutagenesis breeding or somatic fusion (involving cells whose cell walls are temporarily removed) different types of DNA can be moved randomly in the genome.
- Critics point out potential health risks, in particular a higher **allergenic potential**. Proponents argue that such health risks could arise from any food and that in the scope of approval of trans-genic plants, the allergenic potential of newly formed proteins is verified. Furthermore, the toxicity of and modifications to the metabolism of plants is checked. So far, no particular potential hazard in comparison with genetically unmodified crops has been established.
- The transfer techniques generally involve the transfer of marker genes in addition to the target gene. These are used to identify successful transformations. For a long time, antibiotic-resistant genes were used as marker genes, and these are now found in many commercially cultivated trans-genic plants. Critics fear **horizontal gene transfer**[31] **from such marker genes**, in relation to gut bacteria, for example. Proponents believe this to be extremely unlikely, not least because such marker genes are taken from soil bacteria that

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29 EEBA 2008.

30 Thus the European Food Safety Authority (EFSA) and its members are „criticised for not acting sufficiently critically of industry since their previous recommendations in respect of approval of the trans gene varieties up for assessment have always been positive. [...] Behind this is also a lack of confidence in the European authorities, that they will enforce decisions in favour of the consumer and against commercial interests in the case of risk." Boysen 2012. p. 18.

31 A horizontal gene transfer is the transfer or reception of genetic material outside of the sexual reproductive method and across existing species boundaries. Depending on specific prerequisites, a horizontal gene transfer – such as from a crop to a soil bacterium – is generally possible, but is a rare occurrence in natural conditions.

are already widely distributed in nature.[32] Critics and proponents see the risk as more or less important.

- In Europe, trans-genic-plants play a role in the production of feed for animals. Significant quantities, of trans-genic soya for example, are imported. In food, trans-genic organisms play a key role for the generation of enzymes and additional substances that are produced freely in a closed fermentation system. Labelling rules are used here to give consumers a freedom of choice, but they may also be misunderstood as a warning notice. **Labelling rules** themselves[33] are the subject of debate in relation to their design, to the extent that most Germans interpret the term „GM free" as meaning that genetic engineering has had no part in the production process.[34]
- The objective of ensuring a freedom of choice demands that products are split into those that are „GM free" and those that „Contain GM". However, current working practices and cultivation conditions in agriculture do not allow such a black and white distinction to be made, so „coexistence" rules are applied. The purpose of these is to reduce mixtures so far as possible so that there is a tolerance limit of 0.9 percent of GM plant material that can be contained in food. „A zero-tolerance limit (0.0 percent of GM material) would practically mean the end for any cultivation of trans-genic crops. Precisely this zero-tolerance limit is a core criteria for organic products, so the requirement for the registration of GM material is essential for organic farming, and the opposition to trans-genic plants is highest in this area."[35] **Tolerances and minimum distances** can only be seen as compromises, and are therefore up for debate. According to a judgment of the European Court of Justice, honey that contains even only the slightest trace of GM pollen may not be marketed without prior authorisation.[36] There is an authorisation requirement for pollen, which is considered to be an ingredient of the honey, irrespective of the quantity. In particular, this affects honey that is imported from countries in which GM crops are cultivated in greater quantities. The labelling requirements again assume a base threshold of 0.9 percent.
- In view of the open nature of biological systems, once released, GMOs are considered to be **no longer retrievable.** Potential environmental risks include the introduction of the organisms to the wild, outcrossing and harm to other organisms. The actual risks vary according to the type of crop and region of cultivation. Various parties dispute what constitutes environmental damage.

The controversy surrounding green genetic engineering among the general public therefore relates to many different areas and operates at a variety levels, from economics and world view to consumer and environmental protection.

There is also the argument that while green genetic engineering is the target of criticism, it actually represents a bundle of other technologies that appear threatening.

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32 There are no indications of an increased distribution of antibiotic resistance genes among soil or gut bacteria. Following transfer of the cor responding gene, the formation of the resistance would be one stage further on.

33 Food and animal feed that contain GMOs, or are created or produced from them, must be labelled as such throughout the EU since 2004. In Germany, the vendors of food are able to indicate by separate labelling that their products are manufactured without the use of genetic engineering methods. As a result, in line with the special legislative provisions on the labelling of food as GM free that have applied in Germany since 2008, animal feed containing GM crops is permitted outside of a prohibition period, as are accidental mixtures in fodder up to 0.9 percent and fodder additives that are manufactured using GM microorganisms. http://www.bmelv.de/SharedDocs/Standardartikel/Ernaehrung/SichereLebensmittel/Kennzeichnung/KennzeichnungspflichtGVO.html

34 Herrmann et al. 2008.

35 Boysen 2012. p. 12.

36 http://curia.europa.eu/jcms/upload/docs/application/pdf/2011-09/cp110079de.pdf.

2.3 RED GENETIC ENGINEERING

The sea change undergone in the attitudes held by German society in respect of red genetic engineering from the mid-1980s to the mid-1990s is quite remarkable. The transformation, from fundamental scepticism to fully differentiated openness to technology according to different application fields, can be traced back to four aspects:[37]

- In the Federal Republic of Germany in the mid-1980s, questions were asked regarding the ethical issues of applications of genetic engineering on humans. The science was associated with **industrial human breeding**, which must be understood against the backdrop of the racially motivated eugenics and crimes of the Nazi regime.
- The fact that reproductive medicine and genetic engineering found a key alliance in each other in the media and public perception is maybe also due to the contemporaneous advances in reproductive medicine. For example, the world's first „test-tube baby" was born in 1978. However, this debate extended far beyond what is actually possible with genetic engineering, and in recent years it has slipped into the background.
- While health aspects become more important in the debate, the **conflicts between humanitarian and ecological values** became key to it. It was relatively easy to respond to the first genetically engineered medicine (insulin) with a complete rejection of genetic engineering and still not come into conflict with humanitarian aspects.[38] As an example, consider the protests against the construction and operation of a plant by Hoechst AG to manufacture human insulin using genetically modified bacteria. The critics were convinced that starting to make industrial use of genetic engineering should require a corresponding social consensus. As the controversy developed, the security of the plant was also questioned. Finally, the administrative court of the state of Hessen, in Kassel, put a stop to the construction and operation of the plant in a sensational judgment: It said that the plant was approved illegally, since the potential risks and hazards of genetic engineering required legislation. Without a Law on Genetic Engineering, there was, according to the court, no basis on which the approval of a genetic engineering plant could be granted. Such a law was enacted in 1990. This „incursion of control and public participation in the previously largely unregulated sector"[39] has helped to foster the viewpoint among users of genetic engineering that these techniques can only be used unproblematically with clear legislative rules.
- Over the 1990s **medical uses for genetic engineering became increasingly tangible.**

In the meantime, recombinant proteins that enabled new treatments and protection against diseases were available on the market.[40] Such applications had no „GM free" alternatives. The opportunities for genetic engineering in the field of red genetic engineering were growing quickly.

- **Genetic engineering** was **finally differentiated along the lines of individual application areas**. In the mid-1980s, it was still seen as a single monolithic entity, and not only by its critics. Not least due to the work of the Parliamentary Committee of Inquiry „Opportunities and risks of genetic engineering"[41] the debate became differentiated. In the 1990s critics established a sector model that allowed application fields of genetic engineering to be viewed and evaluated separately:[42]

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37 Cf. Wieland 2012.

38 First,porcine insulin could also be obtained and converted into human insulin enzymatically for treatment purposes. Second, forecasts of rising demand for insulin were not founded on a sound basis (Wieland 2012).

39 Dolata 1996, quoted by Wieland 2012.

40 e.g. Interferon, Hepatitis B vaccine, Erythropoietin.

41 See above.

42 Wieland 2012.

Red genetic engineering then started enjoy growing acceptance thanks to its specific benefits for health. In 1996 the Green party adopted the sector model and has since accepted the use of genetic engineering in medicine, as long as there is no alternative.

Today, most Germans agree with red genetic engineering in relation to the manufacturing of medicines and vaccines.[43] After the USA, Germany is now one of the globe's leading producers of GM pharmaceuticals. Debates concerning cloning, research using embryo stem cells and preimplantation genetic diagnosis or screening have not changed the German population's general acceptance of red genetic engineering. Rather, they demonstrate, in contrast to the situation in green genetic engineering, how greatly the individual applications in red genetic engineering are differentiated and criticised in some cases. At the core are usually questions of human ethics.[44]

2.4 WHITE BIOTECHNOLOGY

White (or „industrial") biotechnology uses biotechnological methods - and here specific microorganisms - for industrial production processes. The use of sustainable (rather than fossil) raw materials and conversion of chemical processes to use low amounts of energy and produce less waste are all significant elements of such techniques. The optimisation of microorganisms for industrial production by means of gene synthesis and targeted manipulation of metabolic processes (metabolic engineering) exploits methods of genetic engineering and synthetic biology.[45] White biotechnology products include enzymes, bio fuels, antibiotics, vitamins and amino acids.

The World Wildlife Fund (WWF) has calculated that by 2030, the increased use of white biotechnology will allow savings of between one and two and a half billion tonnes of carbon dioxide, in particular by improving production efficiencies, replacing fossil raw materials with sustainable raw materials and recycling.[46]

Concerns relating to the environment and sustainability that are associated with green genetic engineering are hardly ever transferred to white biotechnology, since normally white biotechnology systems operate in a closed system (bioreactor or fermenter). However, there is an overlap where green genetic engineering is to be applied to industrial crops that are to be used as raw materials.

2.5 SYNTHETIC BIOLOGY

Synthetic biology has emerged on the basis of the findings of molecular biology in the past few years. It is based on the decoding of complete genomes, the technical advance in chemical and enzymatic synthesis of nucleic acids and the possibility of recording data comprehensively at nearly all levels of cellular information processing. Synthetic biology combines a broad spectrum of natural scientific disciplines and follows engineering principles in order to modify known organisms in a targeted, modular approach, or, in extreme cases, to create new organisms that do not occur in nature from basic genetic components.

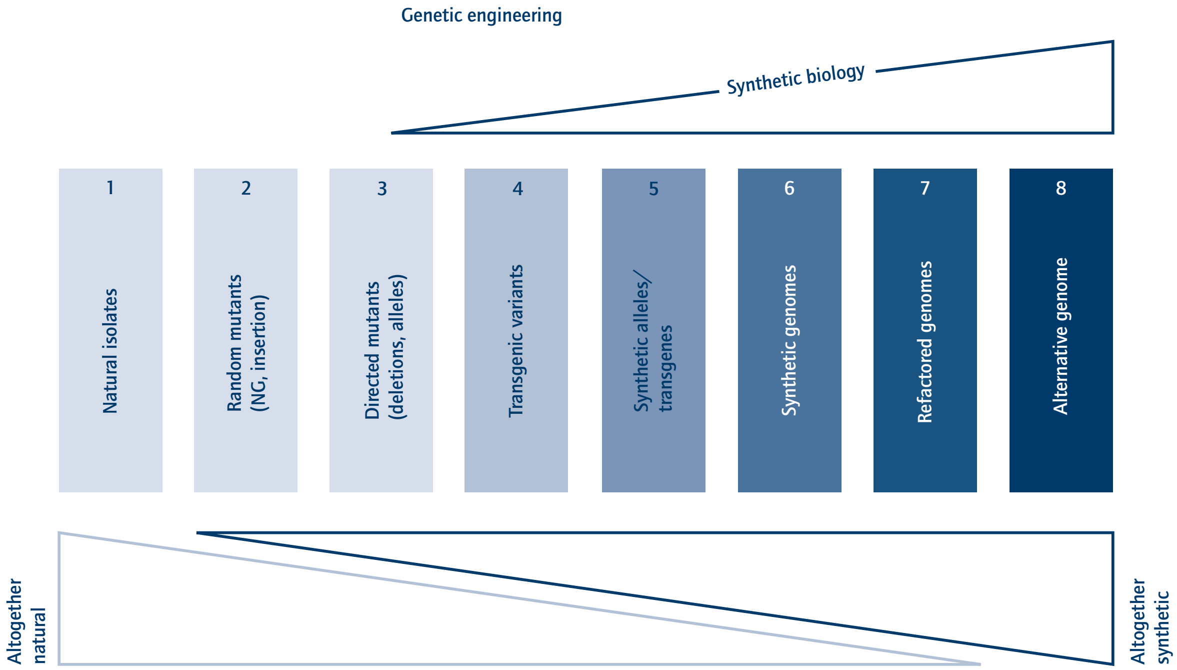
Admittedly, for the foreseeable future it will not be possible to create life from non-living materials – the ethical questions associated with such concepts are all drawn from science fiction.

43 e.g. TNS EMNID 2012, zit. n. Wieland 2012.
44 Wieland 2012.
45 e.g. Zelder 2011.
46 http://assets.panda.org/downloads/wwf_biotech.pdf.

Specifically, scientists are promising new pharmaceuticals, bio fuels and materials made from this new technology. There are conceptional similarities to nano (bio) technology and to green genetic engineering. Actually, the continuum from naturally occurring organisms to completely synthetic life (today purely hypothetical) also represents the relationship between synthetic biology and green genetic engineering (figure 3).

Current controversies thus relate to such different fields as **patent law, biosafety** (i.e. risks from accidental release of artificial biosystems) and **biosecurity** (i.e. the potential for abuse, such as by commercial acquisition of „pathogenic" gene sequences). These challenges relate moreover to vquestions that are discussed in the context of genetic engineering.[47] Among the NGOs[48] that are working on the topic, synthetic biology is sometimes seen as the more radical form of green genetic engineering – the intensity of interventions are said to be more significant than those already not uncontroversial manipulations of green genetic engineering.[49]

Figure 3: The continuum from "natural" to "synthetic" organisms



Source: DeLorenzo 2010.[50]

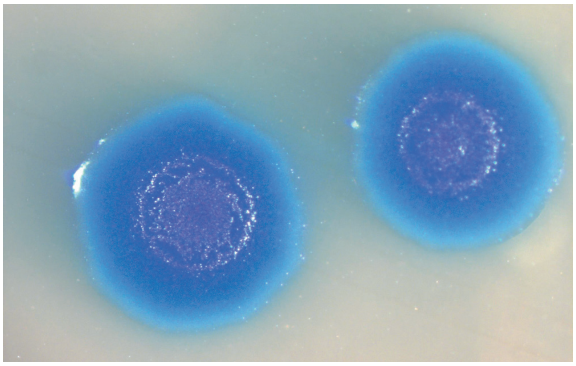
47 Cf. DFG et al. 2009.
48 NGO = Non-Governmental Organisation.
49 For example, etc group, http://www.etcgroup.org/en/node/602.
50 Nach Torgersen/Schmidt 2012.

Questions surrounding the **release of organisms** are at the core of the debate on risk. Synthetic biology can itself be seen as a safety system, if artificial minimal cells or artificial nucleic acids are used as genetic material - such organisms could only fulfil a limited role in defined (laboratory) conditions and would not be capable of surviving in the wild.[51]

According to environmental associations, there need to be specific, legal control mechanisms, „to protect the natural development and evolutionary capabilities of biological diversity.[52] Around the world, Civil Society Organisations have recently signed a paper demanding a moratorium on the release and commercial exploitation of synthetic organisms and their products, so that an appropriate control mechanism can be developed to look after research and regulation in this field, especially in relation to health protection and environmental protection.[53] A short while ago, scientists named specific areas for risk research in synthetic biology, in particular the interaction of synthetic organisms and their environment, and their effects on the natural ecosystems.[54]

Synthetic biology is currently less the focus of public discussion than is nano technology; the term itself is barely used,[55] and no synthetic biology products have yet reached the market. Nevertheless, the US biochemist Craig Venter is generating media attention (figure 4). Headlines such as „**Craig Venter Creates Life**" polarise views between fascination and condemnation. Criticism of such interpretations comes increasingly from the side of science itself: these are not acts of creation, rather much more modestly an improved design for metabolic pathways.

Figure 4: In 2008, researchers at the J. Craig Venter Institute successfully reconstructed the genome of a mycoplasma bacterium. In 2010 a successful attempt was made to implant a synthetic chromosome into such a bacterium and thereby bring it to life.



Source: J. Craig Venter Institute.

In terms of approach and methodology, synthetic biology is also close to information technology.[56] Although the objects of investigation are perceptibly different, similar levels of hierarchical structure („parts", „devices", „system") can be identified. Visual analogies can be drawn between the world of biology and that of computer science,[57] and a parallel dynamic can be recognised.[58] In addition, the iGEM competition for students (see separate box) extends the analogy, as such competitions with free access and no formal prerequisites are well known in relation to robot football or self-steering cars. In this parallel with information technology, the engineer's perspective of synthetic biology in the context of a **„technicisation of nature"** shines through in particular.

51 Cf. DFG et al. 2009, S. 35.
52 http://www.testbiotech.de/node/387.
53 http://libcloud.s3.amazonaws.com/93/11/7/1204/1/Principles_for_the_oversight_of_synthetic_biology.pdf.
54 Dana et al. 2012, S. 29.
55 Gaskell et al. 2010, S.29.
56 Cf. Torgersen/Schmidt 2012.
57 e.g. Yan et al. 2010.
58 The increase in speed and reduction in cost of DNA sequencing and synthesis appears also to be following a form of Moore's Law, just like storage and computing power in computers.

iGEM Competition

The international Genetically Engineered Machine Competition (iGEM) is a competition aimed at students who work in teams, using biological components (BioBricks) in the scope of synthetic biology.[59] The competition is staged each year by the Massachusetts Institute of Technology. Media reporting is oriented around the student teams, and is therefore personalised.[60] The competition sometimes even causes content concerning synthetic biology to appear in the local pages of newspapers. In addition, the iGEM teams are expected to make their own contribution to external communications (outreach). Young people's enthusiasm may cross over into the wider world, and so the students become ambassadors for the new technology.

2.6 NANOBIOTECHNOLOGY

There are numerous areas of overlap between nanotechnology and biotechnology, which are referred to as „nanobiotechnology". Ideas either flow from biological disciplines into nano technology (Bio2Nano) or from nano technology into biotechnology (Nano2Bio).

Initially, debates in the area of nano biotechnology relate to the points that affect nano technology in general and that are the subject of hefty discussion due to the growing marketability of nano products, namely **health and environmental risks.** In respect of the effects of nano biotechnology structures questions relating to health and environmental risks **become more pertinent** when these structures in the context of „Bio2Nano" are **self-organising and capable of evolution**, or when viruses or cell-like structures are involved. Can nano machines, nano robots and nano factories be controlled? Science-fiction literature such as Michael Crichton's „Prey" portray fictitious scenarios of „green goo" - active, self-replicating nano particles that get out of control and spread out into the environment. The starting point for further debate is the desire for nano biotechnologies to operate without restriction with atoms and molecules,[61] or to overcome the limits of Darwinian evolution.[62]

2.7 SUMMARY

It is not biotechnology itself, but a few applications linked with genetic engineering that have given cause for controversy in science and society for more than 40 years. These controversies relate to many aspects, as can be seen in particular in the field of green genetic engineering.

Applications achieve agreement or acceptability when their benefit is evident - such as in the field of red genetic engineering.

White biotechnology, to the extent that it is limited to closed systems within industry, is considered to not be problematic. Synthetic biology and nano biotechnology are open to controversy on a number of points, however.

59 http://igem.org.

60 Cf. e.g. the reports on a team from Bielefeld University, http://2011.igem-bielefeld.de/presse.php.

61 „Man is currently witness to and designer of a second genesis, a fundamental new evolution of material structures for which we do not yet have the correct name.", Binnig 2004.

62 Dyson, F.: http://www.nybooks.com/articles/archives/2007/jul/19/our-biotech-future/.

3 BIOTECHNOLOGY COMMUNICATION: CONTEXTS

Without communication, science is not possible. Today it is obvious that successful dialogue between science and the general public is vital, especially in relation to new technologies that directly affect society. Information and communication can change knowledge and positions. These processes take place within contexts that we shall examine in this chapter.

Existing attitudes in the population,[63] the specifics of individual and group reception and information processing and the social discussion all form the context of biotechnology communication that must be taken into account to ensure that communication reaches the correct target group.

3.1 ATTITUDES

Since the mid-1990s, the Eurobarometer surveys which are carried out at regular intervals have been documenting a stable/ambivalent attitude among the populations of Germany, Switzerland and Austria, as well as those of the rest of Europe, towards biotechnology in general. Support for green genetic engineering is particularly low (table 1). However, the support for biotechnology varies according to the specific application in the areas of red and green genetic engineering and has fallen significantly in some areas in recent years.

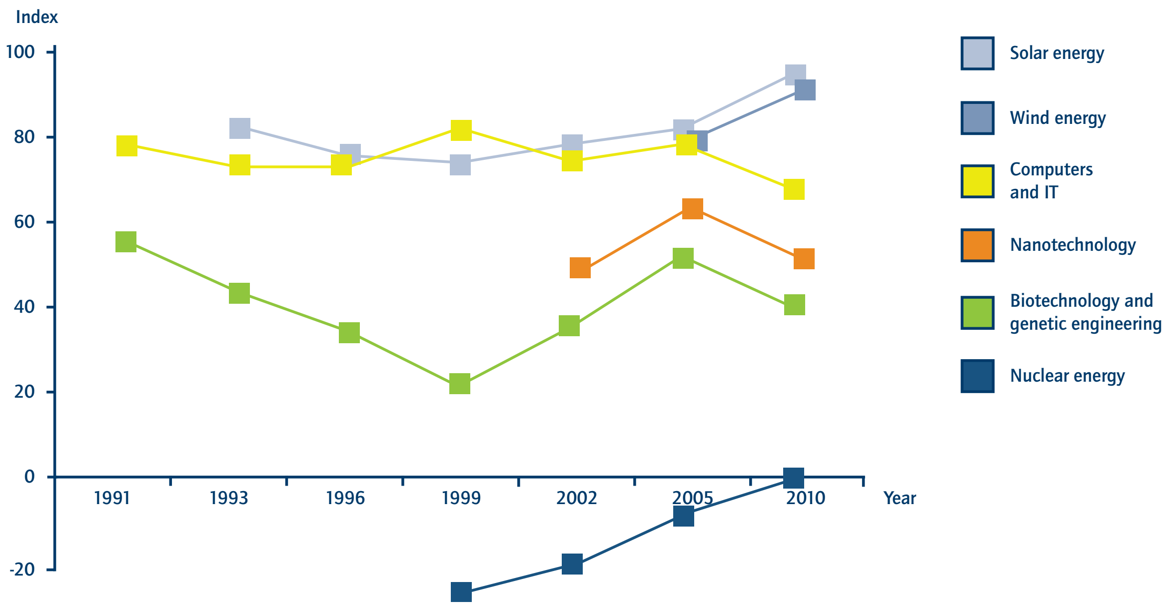
Table 1: Percentage of Population supporting GM food (countries in which GMOs are cultivated are shown in green, those with a prohibition on GMO cultivation are in red).

	1996	1999	2002	2005	2010
United Kingdom	52	37	46	35	44
Ireland	57	45	57	43	37
Portugal	63	47	56	56	37
Spain	66	58	61	53	35
Denmark	33	33	35	31	32
Netherlands	59	53	52	27	30
Norway	37	30	–	–	30
Finland	65	57	56	38	30
Beldium	57	40	39	28	28
Sweden	35	33	41	24	28
Italy	51	42	35	42	24
Austria	22	26	33	24	23
Germany	47	42	40	22	22
Switzerland	34	–	–	–	20
Luxembourg	44	29	26	16	19
France	43	28	28	23	16
Greece	49	21	26	14	10

Source: Gaskell 2012, table. 3.

63 By attitudes we mean entrenched value judgements.

Figure 5: Index of optimism[64] about six technologies



Source: Gaskell 2012, Fig. 2.

In the 2010 Eurobarometer survey, the respondents' general attitude to biotechnology in comparison with other technologies was obtained: "For each [technology], do you think it will have a) a positive, b) a negative or c) no effect on our way of life in the next 20 years?"

This reveals how open the survey participants are to individual technologies (figure 5). For biotechnology and genetic engineering the acceptance index fell heavily in the 1990s, before climbing again to 2005. By 2010, the index had dropped again, as it has also done for nano technology; while the proportion of optimists remained the same for each technology, the proportion of those with pessimistic attitudes rose.

3.2 REASONS FOR ATTITUDES AND THEIR PERSISITENCE

There are no generally recognised explanations for the negative attitudes surrounding (green) genetic engineering. However, a variety of reasons can be adduced:

The fundamental convictions and general perceptions are extremely stable. Values such as religious conviction have a significant effect on perception.[65] The **cultural context** also represents a key reference point that affects the interpretation and evaluation of new technologies.[66] Preconceptions concerning the role of nature play an

64 A positive index is produced when there are more optimists than pessimists, with a negative index when the pessimists outnumber of optimists.
65 Thus a significant negative correlation can be observed between religious belief and the opinion that nano technology is morally acceptable: Scheufele et al. 2009.
66 Peters et al. 2007.

important role in explaining a range of attitudes towards biotechnology. Thus in both the USA and Germany, there is a strong connection between the esteem accorded to nature (in opposition to civilisation) and the (critical) stance towards the use of GMOs in food.

In the meantime, the opinion sometimes previously argued by proponents of biotechnology, that a lack of information among the population and/or lack of confidence in the players and regulatory instances bore most of the blame for a lack of technology acceptance, has been disproved. Studies have consistently demonstrated that **more information** does not produce broader levels of agreement, but rather to greater **polarisation of existing positive and negative attitudes**.[67]

Survey findings such as those produced in the scope of the Eurobarometer series along with sociodemographic data reveal a connection between **educational background** and information acquisition. The tendency for respondents to obtain information on a topic or to talk about a topic rises in line with their level of education.[68]

According to the findings of many studies, there is no basis for the assumption that Germans are particularly anti-technology. Actually, they are **acknowledged to have a clear interest in technology**. A rejection of technology for its own sake is rare, and normally relates to individual fields of technology.[69]

Green genetic engineering is associated with low levels of **benefit** and high risk and there are also moral concerns. In contrast, the majority view of red genetic engineering is that it is very beneficial.

In respect of risk perception, there are clear distinctions between the evaluations of specialists and lay persons, since the latter assume simpler heuristics.[70]

A decisive factor is the **trust** of lay persons in the relevant stakeholders. Given the level of differentiation in academic knowledge, however, most people are lay persons in just about every domain. Thus we all must frequently rely on the knowledge of experts. Aspects of trust and credibility thus play a decisive role in our dealings with scientific information, when we encounter information that we cannot evaluate ourselves. For example, in the USA Brossard and Nisbet established that it is the credibility of experts that has the largest effect on obtaining a position attitude to green genetic engineering:[71] the topic is considered complex not particularly relevant to everyday life, so we must trust the scientific experts. In this context, it is notable that in Europe – in relation to biotechnology and genetic engineering – the past decade has witnessed a rise in confidence in the actors from science and industry.[72]

3.3 RECEPTION

The principle motivation for lay persons in receiving scientific content is not to acquire knowledge (in the sense of education for its own sake), but to find solutions and approaches to dealing with everyday problems.[73] In particular, the preconception that lay persons might be prepared to work through masses of information in order to come to the best conclusion should be completely rejected. Instead, we are all initially what are referred to by Scheufele as “cognitive misers”, whose desire and need is to reach decisions as efficiently as possible – especially in topics and situations in which there

67 Kahan et al. 2009.
68 e.g. http://ec.europa.eu/public_opinion/archives/ebs/ebs_341_de.pdf, p. 41 and 43 for nano technology.
69 Cf. Jakobs et al. 2009.
70 Cf. Bromme/Kienhues 2012; Bonfadelli 2012.
71 Brossard/Nisbet 2006.
72 Gaskell 2012, tables 1 and 2.
73 Cf. Bromme/Kienhues 2012.

is no specific attraction for us to go into specific detail or to consider the information for too long.[74]

Lay persons select and process scientific information according to their own particular motivations. So the influence of attitudes on information processing is determined to a certain extent by the amount by which the two overlap (the "message congruency effect"). According to this concept, information that is message-congruent with the recipient's personal attitudes generates a greater level of trust than information that is message-incongruent.[75] However, we do not focus our perspectives so tightly that we only seek out the information that confirms our own viewpoint. Rather, in general we prefer information that is balanced.[76]

Cognitive conflicts may be circumvented in a surprisingly diverse number of ways, and therefore do not necessarily lead to a transformation of knowledge structures or attitudes among the recipients. As a result, it is necessary to distinguish knowledge content into "everyday" and "scientific" if existing concepts from the "everyday" world are not to be attacked by the emergence of innovations in the "scientific" world. Observations that fail to meet expectations can also simply be ignored or reinterpreted in the context of the previously held conviction.[77] Thus, troublesome feelings of **cognitive dissonance** that can arise when confronted with new information that clashes with preconceptions are often eliminated in a way that leaves the stable attitudes unchanged.

In parallel, basic assumptions and values act as a **filter**, through which new information such as that concerning complex scientific content must flow. "[A]udiences use their own value systems or beliefs to interpret factual information and translate them into consistent policy stances or consumer attitudes."[78]

Information that does not match the recipient's own beliefs is more likely to be accepted if it is advocated by experts from a range of orientations or value systems, possibly from different sides of a controversy (an effect known as "pluralistic advocacy").[79]

The same information content may be received differently according to how it is **framed**. The framing may take the form of terminology or an image that is used to depict a complex scientific situation.[80] The issue of how to frame information on controversial topics so that people from different backgrounds are able to reach the same conclusions is yet to be resolve.[81] The effect of **metaphor** is significant.[82] For example, framing with language such as "Frankenfood", "artificial life" and "Terminator technology" obviously does not create a good context for objective communication.

The boundaries between specialists and lay persons[83] are fuzzy and can no longer simply be defined by a level of knowledge.

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74 Scheufele 2006.
75 e.g. with reference to GM food, Meijnders et al. 2009.
76 Wilson et al. 2004.
77 Chinn/Brewer 1993.
78 Brossard 2012.
79 Kahan et al. 2011, p. 31.
80 Brossard 2012.
81 Kahan et al. 2009, p. 87-90.
82 Nehrlich et al. 2009.
83 In their expert assessment, Bromme/Kienhues explain their use of the terms „lay persons" and „experts". The former refers to people who have no formal education in the related scientific discipline and who typically are not institutionally or professionally occupied with scientific topics. However, they are occupied with or affected by such topics in some way (e.g. as consumer or as a patient). For that reason they also have knowledge about the topic. Such „informed lay persons" possess knowledge that is equal in parts to that of the „experts" and in some cases exceeds it (e.g. Collins/Pinch 2000).

In particular, alongside the flow of information from experts to lay persons, information exchange between (informed) lay persons is of increasing importance for spreading knowledge. In terms of the psychological effects of reception, therefore, not only the individual's information processing is relevant, but also their capacity for communicative processing, for example in group dialogs or in blogs.

3.4 POSITIONS HELD BY THE SCIENTISTS

Alongside the widespread public attitudes, the **scientists' understanding of the public** (their attitudes to the population, media and dialogue forms) also provide a context to scientific communications.

Scientists believe that the general public's knowledge of science is low and that most people reject technology or come to a false view of science and technology due to a lack of information. Science is thus still a significant prisoner to the deficit model. According to this viewpoint, idea spreads that the general public is generally uninformed.[84] Scientists consider their first task to be to inform the population (primarily through the media) of the advantages of new technologies.[85]

Scientists are general quite critical of media reporting. The media are accused of paying too scant attention to whether the scientific findings on which they are reporting are substantiated.[86] Personal experiences with journalists, in contrast, are largely positive, and these contacts are seen as good opportunities for informing people outside the scientific community.[87]

Nevertheless, scientists are rather sceptical about forms of dialogue. Of those who are actually aware of dialogue forms – only a quarter in a survey of the American Association for the Advancement of Science (AAAS) conducted in 2009 – just about half consider such dialogue to be useful for the general public and for decision-makers, and only a third believe they can benefit from it themselves.[88]

3.5 SOCIAL DISCOURSE

Since the mid-1990s, researchers in social science and communications science have conducted in-depth studies of the controversial public discourse around biotechnology (especially green and red genetic engineering).[89] Genetic engineering and especially its applications for agriculture and in food generate an ambivalent or even negative response among the population, not only in the German-speaking countries of Germany, Switzerland and Austria.[90]

There are currently very few signs of a general increase in support for genetic engineering (table 1, page 23). Some say a consensus had been established among the dissenters, and so the controversy had actually disappeared.

Even though red and green genetic engineering are pushed by science, research and industry as new technologies that have a promising future, and thus receive corresponding support from individual governments and are also well funded at EU level, the discussion in the public arena has become or has remained controversial. There is a conflict between the following stakeholders:

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84 Davies 2008; Besley/Nisbet 2011.
85 Petersen et al. 2009.
86 http://www.people-press.org/files/legacy-pdf/528.pdf, p. 22.
87 Peters 2012.
88 Petersen et al. 2009.
89 In Bonfadelli (2012) and Hampel (2012) many of these works are summarised, whereby rich empirical evidence is available on a range of specific questions, theoretical perspectives and methods (Bonfadelli 2012; Hampel 2012).
90 After Bonfadelli 2012.

- the proponents in research and industry, who want to ensure that biotechnological innovations succeed and create biotechnology-friendly regulatory regimes,
- opponents such as NGOs and other civil society bodies that aim to create a countermovement by agenda setting and distribution of counterclaims, but also politicians and political parties that aim to exploit such topics to attract and mobilise members and voters,
- representatives of agricultural and farmers' associations, who range from ambivalent to rejecting,
- public authorities who wish to regulate the sector as neutral bodies, and
- the media.

Against the backdrop of a politically induced moratorium on genetic engineering (initially from 2005 to 2010 and then extended to 2013), the controversy in Switzerland has reached a complete deadlock:[91] There are no longer any markets, nor any products, nor any field trials in that country. All of the cards have been placed on the table, and no side appears to have anything new to play. It appears that the ceasefire is generally welcome and is saving resources. Conversations with experts[92] indicate that the various stakeholders have each identified different scapegoats to criticise. In the dock, for example, are those behind the media headlines, with their reporting, the scientists with their research, the agriculture industry with its corporate strategies and the people with their political (mis)conduct.

In the intercultural comparison of Europe and the USA, increasingly the picture is of greater acceptance of biotechnology in the USA.[93] However, US citizens know comparably little about GM food and biotechnology. The support for GM food has been relatively stable, if not strong, in recent years.[94] However, it seems this support is now starting to fall in the USA too.[95] In contrast to the discussion in European countries, the battle lines here have not become entrenched. This may be due to the low level of knowledge: Thus attitudes may be transformed relatively easily through new information, on new applications that have direct consumer benefit, for example, or through a food scandal.[96]

3.6 SUMMARY

Existing fundamental convictions, attitudes and everyday preconceptions in society are key factors for science communication. They are all generally remarkably stable, and are not changed directly by the reception of different content. They feed the discussion within society, which forms its own frame in which the activities of science communication occur.

91 Cf. Bonfadelli/Meier 2010.
92 Bonfadelli/Meier 2010.
93 Hossain et al. 2003.
94 Fink/Rodemeyer 2007, p. 127.
95 Brossard/Shanahan 2007.
96 Brossard/Shanahan 2007. p. 158.

4 COMMUNICATION AND PARTICIPATION

This history of biotechnology communication has, since the 1970s, been at the centre of a revolution in scientific and technological communication „from deficit to dialogue".[97] The term „Public Understanding of Science" (PUS) has been used since the 1980s, first in Anglo-American circles and then slightly later in Germany, to identify a movement that started in thenatural sciences and that refers to the relationship between science and the general public. The term became widespread in 1985 as the title of the „Bodmer report"[98] . The report postulated that British scientists had too little contact with the general public. Since the 1970s at the latest – in parallel with the protests against nuclear power – the public have become sensitised to the associated hazards to the point of alienation with the technology. Given the situation in which research is funded largely from public money, the Bodmer Report points out a basic problem of legitimacy.

The „Public Understanding of Science" suggests, however, that the main problem lies in the lack of knowledge within the general public.[99] This deficit model does not only run counter to the growing demands for democratic participation, but has also been proven to be empirically wrong.[100] In Germany and abroad, scientific communication has, therefore, changed fundamentally in recent years. While previously the reasonable communication of knowledge by experts focused on public interest, dialogue-based models are now becoming increasingly important. They are particularly suited to being used as participatory formats when attempting to communicate scientific expert knowledge along with the values, visions and desires of average citizens.

4.1 ROLE OF THE MEDIA

Whether deficit model or dialogue formats, a major player in communication is the media. The importance of the media is a product of the assumed or implied influence it can exert on the general public. The **media effect** is, however, **significantly lower than previously thought**. Instead of forming the attitudes and behaviour of individuals and the public at large, the media is now accorded simply an **agenda-setting function**, according to which the media has a large influence on what is discussed, but is not able to affect the arguments or framing of the discussion. Recipients are selective in their acceptance of media reporting on genetic engineering, and interpret the information selectively against the backdrop of existing attitudes and cognitive frames for and against genetic technologies. The tendency is for **existing opinions to be confirmed and reinforced**. When this happens, it is possible for articles that are positive in their evaluation to be read „against the grain".[101] Communication objectives can be supported by the media; a media presence is then necessary, but insufficient on its own.

From the perspective of the natural sciences and of biotechnology on the one hand and commercial risk management on the other, as well as of politics, it is often asserted and declaimed that media reports overemphasise the negative aspects of new technologies, and their risks and the damage they cause. In contrast, consumer organisations, environmental groups and NGOs sometimes accuse the media of approaching technology without a sufficiently critical viewpoint.[102]

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97 Cf. Lock 2011.
98 This report was commissioned by the Royal Society and written by a group based around the human geneticist Walter Bodmer. Bodmer 1985.
99 House of Lords 2000.
100 Kahan et al. 2009.
101 Peters 1999.
102 Such criticism of distorted or distorting reporting by the medium naturally implies that there is a valid scale against which reporting on a topic can be verified for its accuracy. In general, criticism of the (allegedly negative) media reporting is not confirmed. Cf. Hampel 2012; Bonfadelli 2012.

The "Gen-Welten" ("Gene Worlds") project and exhibition
In the mid-1990s, a number of museums and art galleries responded to the increasing importance of genetics and genetic engineering with the idea of staging an exhibition on the topic. Five institutions in Germany and Switzerland formed an association to raise the visibility of the topic in a range of parallel perspectives and emphases. The reflection context of the exhibitions staged in 1998 and 1999 should - according to the museums' own claims - be larger than the biotechnology fields of genetics and genetic engineering themselves. Discussions on science and technology were staged as part of a fringe programme. The objective of the project was "to heighten the awareness of how genetics and genetic engineering affect our everyday worlds, beyond all of the sensationalist headlines. The exhibitions aimed to provide people with the tools to develop their encounter with the topic. There was to be no focus on evaluating the content. Visitors should be encouraged to make up their own minds".[103]

One critical analysis established that hardly anyone turned up: "Instead of the expected 1.2 million visitors, not even half that number had turned up by the end, and that included schoolchildren who had been bussed in at the museum's own cost".[104] A parallel sociological study[105] criticised this as an attempt to stage a crash course in genetics and genetic engineering, as well as putting forward the idea of the "neutrality" of scientific and thereby ignoring the evidence from research into the risks and consequences of technology. Those looking at the project from a biology education perspective, on the other hand, criticised it for not paying adequate attention to the great interest of the visitors (especially in questions relating to human medicine) or to addressing their knowledge deficits or problems of understanding in the exhibitions. Despite the massive media mobilisation (models, films, computer use, posters), the general principles of genetic engineering were not successfully communicated.[106]

It is clearly evident here that there are contradictory expectations of the exhibitions and their function in Science communication. In a self-critical retrospective, one of those behind the exhibition stated that the objectives of the Gene Worlds association "that its guiding premise of teaching the socially attractive topic of genetic engineering by providing 'objective' information [...] were questionable, if not actually untenable."[107] Simply the selection of topics, the accentuation and the selection of images and exhibits entailed the taking of a position. However, this was not done transparently, but in a way that suggested "objectivity". "Subsequent exhibitions on similar socially controversial 'life sciences' topics certainly had to pay more attention to ensuring that the thematic design of the exhibition was transparent and that the motivations of the sponsors who support the exhibition with funding and exhibits are clearly explained."[108]

It appears as though, as a result of the media society, the frequency and amplitude of exaggeration in each communication is increasing, while the amount of objective information content in terms of a weighing up of benefit and risk remains the same.

In fact, increased reporting does not guarantee greater objectivity.

A more detailed analysis of the reporting reveals a differentiated picture: The reporting can be investigated using

103 Wenzel et al. 1998, p. 7.
104 Schmidt 2001.
105 http://www.uni-bielefeld.de/fb19/11b11.htm.
106 Krüger 2000.
107 Seltz 2000, p. 105.
108 Seltz 2000, p. 106.

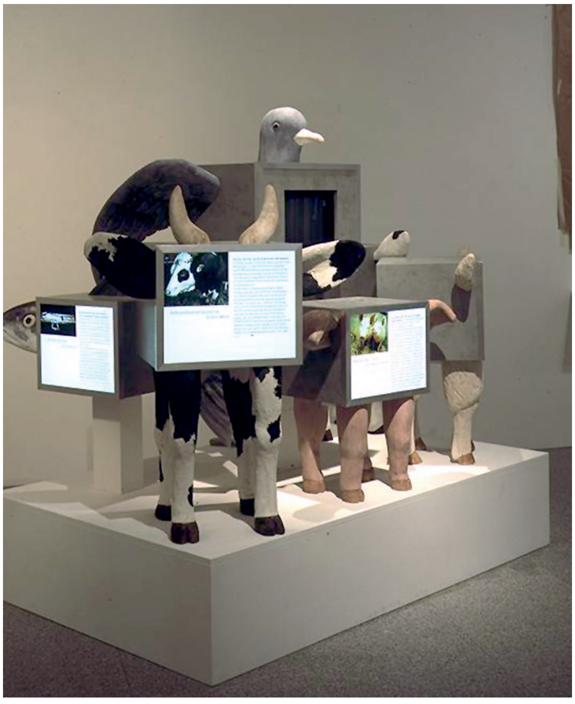
standardised quantitative analysis of the content, especially in the form of long-term studies.[109] These have shown that at the end of the 1990s, reporting on genetic engineering in the German media was dominated by representatives of science. The media highlighted the benefits (especially in the field of medicine) far more than the risks. Reporting on genetic engineering in the 1990s avoids anecdote and value judgements and can be considered as a neutral source of information: "Criticism and warnings of risks relate clearly to those genetic engineering methods with applications that have been or can be deemed to be neither plausible nor necessary."[110] This assessment can be confirmed currently by considering the reporting on synthetic biology, in which expected benefits clearly outweigh the expectations of risk.[111]

If one considers the direction of reporting, i.e. whether the media is reporting genetic engineering in a positive or negative light, the trend of ratings awarded to the articles does not reveal a constant picture.[112] The most positive image of genetic engineering in the media was seen between 1973 and 1981. By the mid-1980s, most reporting was typically framed in a context of progress.[113]

In respect of the intensity of the reporting and the value judgements it makes, the following can be said: The more negative the context, the more intense the media reporting. This result can be interpreted to indicate that the volume of "bad news" is generally greater. It is an effect that may reinforce the scepticism on behalf of newspaper readers, since the risks are simply more abundant in terms of simple numbers.

In the USA, too, media reporting of genetic engineering rose steadily from the 1970s to 1999. It is described as extremely positive. Overall, however, it is revealed to be rather episodic and tied to specific events. As in Europe, media reporting of genetic engineering in the USA is taking an increasingly negative viewpoint. Although with greater media reporting the positive contexts are also rising. This can be attributed to the

Figure 6: "Transgenic animals" at the Gene Worlds exhibition of the Kunst- und Ausstellungshalle in Bonn. Fish, a goat, pig, sheep and calf represent different types of genetically modified animal with the various applications.



Source: Neal Potter Design Associates, photograph: Peter Oszvald, Kunst- und Ausstellungshalle der Bundesrepublik Deutschland.

109 For methodological reasons, the focus is often on print media, frequently on quality newspapers and magazines, although the position of the television as the most important channel for distributing information about genetic engineering is recognised. The quantitative analyses are complemented by qualitative analyses of the media discourse, analyses of the metaphor and images used and interviews with experts.

110 Merten 1999. p. 339 (translation).

111 Gschmeidler/Seiringer 2012.

112 Bauer/Gutteling 2006, p. 121.

113 Hampel et al. 1998.

fact that the participants in the controversies on all sides are expanding their lobbying efforts to include the media.[114] As in Europe, sources of reporting through into the second half of the 1990s in the USA were dominated by participants from science, politics and the industry. Reporting, therefore, was rarely concerned with controversies and decisions, and more with scientific "progress" and commercial expectations. It was only in the second half of the 1990s, when cloning and green genetic engineering became subjects for discussion, that media reporting first started dealing to any notable extent with questions of ethics, risks and responsibility.

When considering the media reporting over a longer period and after putting it into the context of political and social debate, the very event-oriented nature of reporting can be clearly observed. Thus, an analysis of the reporting of biomedicine (period 1995 to 2004) reveals that the frequency of reporting is determined by key **trigger events** such as press conferences.[115] This trigger effect can also be confirmed by analysis of the reporting of synthetic biology in the period 2004-2009.[116] One third of German-language reports on synthetic biology were focused on a publication of a statement by DFG, acatech and Leopoldina.[117]

Activities aimed at i**nfluencing media reporting** are not only found among scientists, but also among NGOs that reject certain technologies, such as nuclear energy or green genetic engineering. NGOs are extremely successful at launching campaigns that activate the media's selection mechanisms.[118] Events are staged in order to obtain images for the media. As a result, some observers declaim the influence of NGOs on reporting, which goes so far that "not the journalists but the media experts hired by Greenpeace [...] control agenda setting and public opinion on environmental issues".[119] This observation raises the more general question of the extent to which the battle around technical/scientific issues shifts according to which side is able to successfully place its position in the media.

In respect of new technologies such as synthetic biology, exaggerated representations often warn of a major potential threat. Such exaggeration is often simply a side effect of the **race for media attention**. Science highlights the innovation and high level of relevance of the experiments,[120] while NGOs exaggerate even more in their struggle for attention for synthetic biology, to the extent that they even have to exceed the horror scenarios they came up with for green genetic engineering. Politicians have to explain the funding that is allocated to research and development to a sceptical public, and that too is easier if the prospects include socially desirable futures.

4.2 ONLINE MEDIA

Online mediaisbecoming increasingly important, not only as a channel for obtaining information, but in particular for allowing direct exchange.[121] People use social media to publish texts, video and other content, and to communicate with each other. Interactive (so called web 2.0) platforms are numerous and diverse, ranging from the online encyclopaedia Wikipedia via the YouTube video platform and Facebook, the social network, to virtual worlds such as Second Life and the micro blogging platform Twitter. It is anticipated that social media will grow further, while

114 Nisbet/Lewenstein 2002, S. 384.
115 Weingart et al. 2008.
116 Gschmeidler/Seiringer 2012.
117 DFG et al. 2009.
118 http://www.greenpeace.de/themen/gentechnik/.
119 Baringhorst 2000, S. 179.
120 So das J. Craig Venter Institute in seiner Pressemitteilung zur „ersten sich selbst replizierenden synthetischen Bakterienzelle", vgl. dazu etwa Schummer 2011, S.113.
121 Brossard 2012.

the benefits of using traditional media options continue to decline.[122]

Information and value judgements continue to converge, as people comment on online news or indicate their preferences using "Like" buttons. Actually, online news messages are interpreted differently according to the comments that are added by users. Even if the information source is known to be reliable, coarse comments can make the news item appear implausible.

In relation to science communication, the journalists' role as information sifters is being lost in the transition from traditional mass media to online media. It may be that **new gatekeepers** will grow into the role: The two-stage distribution of information, first from one information source to a variety of "multipliers" and from there to a broader public, seems to hold true for online media too. Particularly active social media users can help to distribute specific information and opinions. Such channels are recognised and used increasingly by marketing experts, but also by activists[123], in order to spread a message quickly and effectively.

Web 2.0 is therefore a reality for the field of scientific communications, too. "The question to ponder, therefore, is not if and when these new realities will impact science communication, but instead how this transition will progress and how it will shape the communication dynamics surrounding (controversial) scientific developments, such as biotechnology."[124] Scientists must participate actively in order for evidence to be included in the basis for the formation of opinions. If they do not join in, other groups will simply take their place.

amflora.de

The dialogue platform amflora.de set up by BASF to mark the first cultivation of Amflora was intended to provide interested members of the population with information, and introduce controversial topics and the corresponding BASF arguments – sometimes directly from "in the field". The specific dialogue formats comprised blogs, with options for commenting and asking questions.

Even though the actual objective, of increasing the acceptance level of green genetic engineering, was not met, the scientists behind the initiative have gathered experience for further projects of this type. There has been no major clash on this platform, and critics have exercised moderation in their postings. In fact, amflora.de has been mentioned in critics' own blogs.[125] No "new" arguments have been made. The effort to manage the website from an editorial perspective was therefore reasonable.

4.3 DIALOGUE AND PARTICIPATION

Science policy has also long recognised that responses to core contemporary challenges such as climate change and a shortage of resources should take account of the needs, concerns and expectations of citizens.[126] Options for information (monodirectional communication), dialogue (bidirectional communication) and participation (with opportunities for influencing the decision-making process) form instruments for this process that represent a continuum of increasing intensity and interactivity in the relationship between the communication partners.[127]

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122 Mende et al. 2012.
123 e.g. http://www.nongmoproject.org/
124 Brossard 2012.
125 http://blog.greenpeace.de/blog/2010/04/19/sektlaune-auf-dem-gentechnik-acker/
126 http://www.buergerdialog-bmbf.de/allgemein/buergerdialog.php
127 e.g. Renn et al. 2005.

Decisions made on such a broad basis must not only be reasonable in terms of content, but must also be socially robust:[128]

- Alongside transparency and legitimacy, participation is a fundamental pillar of a sustainable and stable democratic state.
- Science and Technology Studies (STS) investigations into the production of scientific knowledge have demonstrated in many different examples that such production is not objective but guided by specific interests. In addition, relevant expert knowledge can also be found outside the scientific community.[129]
- Ultimately, when it comes to answering complex questions around social values, the broadest possible range of views must be considered.

"Dialogue" has steadily gained importance as a form of scientific communication and has become the standard on the international stage for at least the past ten years.[130] Dialogue entails bidirectional understanding. It is not simply about the public learning about "science", but also about the feedback loop back from the public to the scientists. The representatives of science, commerce and politics who are involved hear opinions and emotions from the general public and understand existing uncertainties better for themselves (see the "Citizens' conference" box for an example).

Dialogue can only fulfil its function if it offers options and is unbiased. In generally, therefore, dialogue is a necessary condition for supporting technology, albeit insufficient on its own. Dialogue may also exacerbate conflict,

Citizens' conference "The Genetic Screening Controversy"

In autumn 2001, the Deutsches Hygiene Museum in Dresden staged the first German "citizens' conference", on the topic of "The Genetic Screening Controversy".[131] In total, 19 citizens took part in the process, which took the Danish consensus conference as its role model. They came together over three weekends to discuss the use of genetic testing methods for predictive diagnosis and pregnancy care, producing a topic-based differentiated statement at the end of the process.

A parallel evaluation showed[132] that the participants' level of knowledge rose significantly over the course of the process.

This is not particularly surprising given the intensity of their encounter with the topic. "Those who came to the conference with a pre-existing opinion on one area of genetic screening or another used the range of new information to underpin their arguments and cement their opinions."[133] Those who had no clear opinion before the conference underwent a process of weighing up the arguments on genetic screening. The opinion forming process was extended beyond the scope of the citizens' conference itself, as participants discussed their experiences with others from their own environment. "Interviews revealed that some of them had gained "expert" status on genetic screening issues in their social environment, and their opinion carried a correspondingly great weight."[134]

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128 Cf. Einsiedel 2012, see also above on Nowotny et al. 2001.

129 Thus the boundaries of technical expertise were clear in, for example biomedical research, agricultural policy and transnational environmental debate. A metastudy of the American Association for the Advancement of Science (AAAS) investigated forms of communication and participation used in environmental initiatives and as a result derived recommendations for politics, the economy and society from over 800 individual studies: Dietz/Stern 2008.

130 Cf. House of Lords 2000.

131 Schicktanz/Naumann 2003.

132 Zimmer 2003.

133 Zimmer 2003. p. 71 (translation).

134 Zimmer 2003. p. 73.

since it offers criticism a forum, or opportunity, to present itself.[135] In fact, green genetic engineering has itself been the subject of many dialogue events, but has not gained extra support from society as a result. Dialogue is, however, a suitable method of increasing the legitimacy of a process.

In the past, communication was often only used once the technology had been developed and all opinions were already entrenched. There is, therefore, a consensus in science studies that communication with the general public should occur upstream – at an early point in the development of the technology. Nanotechnology was the first new technology to be the subject of comprehensive proactive communication using "new" methods and participatory approaches, even if this has still only reached a limited audience. Upstream engagement can, however, only be used meaningfully when applications or other implications for society are at least within sight.

An example of participatory formats are the consensus conferences, that took place in the mid-1980s in Denmark. In fact this technique has spread throughout many countries - particularly on topics such as green genetic engineering and red genetic engineering.[136] In a consensus conference, a group of around 20 citizens who have been selected according to criteria to ensure good demographic representation work together. The activities of those involved in this process, the organisation of which is extremely complex, include: obtaining information, identifying the key topics, listening to experts, consulting, and writing the final report to be presented to the general public, media and politicians.

4.4 SUMMARY

Numerous actors and diverse activities have referred to biotechnology communication in the past decades. However, instead of systematic evaluation, so far only anecdotal evidence has been available in respect of the extent to which objectives have been formulated and achieved, and of the relationship between effort and benefit in terms of information, dialogue and participation. Great potential is envisaged in the use of Web 2.0 options and personal dialogue formats.

[135] Cf. von den Daele 2012.
[136] Einsiedel 2012, table 1.

5 CONCLUSION AND RECOMMENDATIONS

A broad range of diverse formats are available for communication and participation. There are now several guides, manuals and handbooks on the issue of which formats are suitable for various topics in various contexts. However, there is still no panacea: Communication and participation must always be adapted for the unique nature of each situation.

Controversies are important and cannot be swept under the carpet by communication alone. They are a significant element both of acquiring scientific knowledge and communicating scientific knowledge. Pointing to public controversies as "a lack of acceptance" of science or technology is missing the point. In terms of political decisions relating to science, there are always winners and losers, just as with any other political decision. One of the objectives of communications should be for representatives of the minority position to perceive the communication as fair and be able to acceot the other position without giving it their support.

The fact that genetic engineering applications would generate controversy was clear to the participating scientists around 40 years ago, when the molecular biological methods were being developed. Initially, the focus was on questions of biological safety. When the debate reached the general public, it had expanded to include aspects relating to economics, benefit, innovation, ethics and the law. A differentiation by application has made the controversies surrounding biotechnology even more diverse. Thus, concerns that relate to environmental protection and sustainability of green genetic engineering cannot really transfer to white biotechnology, with its closed systems of production. The situation of synthetic biology is somewhat different, since it is viewed as a radical form of genetic engineering, in which the issues of biological safety and security and patenting that are already known in relation to green genetic engineering have been taken on board.

The context, or framing, of biotechnology is key to its communication. For example, communication on synthetic biology could align itself with green genetic engineering, nano technology or information technology and each variant would carry different references and expectations. In relation to green genetic engineering, references to food, naturalness, irretrievability and lack of consumer sovereignty in decision making could dominate. Framing may include social progress, commercial opportunities or scientific uncertainty. In some contexts it may be useful to avoid certain terminology, in order to prevent an inappropriate framing such as "artificial life".

Past experience shows that it is futile to hope to influence existing attitudes in the population. Rather, these attitudes – as well as features of reception - must be taken into account as part of the context in the design of communication and the desired reception. Positions that are widespread among science and in some instances still stuck tothe deficit model are also relevant. Thus many scientists believe that the benefits of new technologies will be overlooked due to the lack of information among "ignorant lay persons", even though concerns about the risks of new technologies are frequently registered by more educated classes.

Recommendations to science and industry

(1) **acatech recommends that the sources of information be made transparent and that scientists reflect on the objectives of the communication.** Who is the expert? What are their interests and objectives? Is the purpose of the communication to provide information, to query potential concerns or to increase an openness to the technology perhaps even to acquire acceptance? Is the communication to comprise a dialogue with stakeholders, or should it be an integrative process of involving the public in decision making, regulation and innovation? The most suitable communication formats should be selected

according to the objective and adapted. In particular, a clear distinction must be drawn between communication processes and participation process. Participation is only appropriate if there are pending options that can be decided by participation of stakeholders or the general public. In the case of participation process, the context, objectives and mandate must be clarified and disclosed. The communicative objective must also be clearly identified for communication processes.

(2) **acatech recommends that the authors of the communication consider which sub-topics should be included.** For example, when defining fields such as synthetic biology or nanotechnology, the actual topics for discussion must be clearly identified in order to ensure objective communication. Does the communication concern existing research or applications, or utopias and dystopias that may occur in the future? Discussion topics must be specifically identified within the broader fields such as green genetic engineering.

(3) **acatech recommends that not only the knowledge content but also the processes of knowledge gain in the corresponding branches of science, the methods of assessing risk and opportunities and the procedures for political regulation should be communicated along with the findings.** Communication must demonstrate how findings have been arrived at, what uncertainties they are subject to, what interests they are allied with and how industry and government will conduct preventive risk management.

(4) **acatech recommends that scientists who, as communicators, already invest significant resources in terms of funds and time, strive to increase their visibility and maintain credibility in the eyes of generally less specialised but in media terms more strongly represented opinion formers.** As the recipients are unable to verify the verisimilitude of scientific statements themselves, the credibility of the communicators is especially important. The credibility indicators comprise, among others: Complete transparency of all studies and research results, disclosure of own interests, clarity concerning remaining uncertainties and non-knowledge and disclosure of plans for crises or accidents.

(5) **acatech recommends, for the purpose of targeting specific groups, taking a more problem-oriented approach to communication with the general public rather than a technology-oriented approach.** Thus the opportunities for the environment, nutrition and resource protection must be highlighted. At the same, risks and uncertainties must be discussed and the ways in which these risks can be limited, uncertainties observed and potentially counteracted must be stated.

Recommendations to scientists, industry and politics

(6) **acatech recommends that the positions and value judgements held by individual stakeholders, including those outside the scientific community, be treated with respect throughout all communications processes, and to be given due, serious consideration, without prejudice. In relation to the dialogue between science and society, options need to be investigated for ensuring that information and opinions are gathered and received systematically from the general public by science and industry.** The public (for example NGOs) should be included in a dialogue on new technologies at an early stage. Expert knowledge and lay persons' perceptions should be seen as complementary, rather than seen as contradictory. Specific consideration must also be given to how the finite resources of the communication partner can be utilised most efficiently and constructive. This may involve remuneration of representatives of civil society organisations for their collaboration in an honorary capacity. The expectations, desires, hopes, fears and criticisms of lay persons must be recorded and taken into account when designing the innovation processes. At the same, expertise from science and industry are vital for a scientific debate based on evidence, so as to counter absurd or untenable expectations or fears.

(7) **acatech recommends that a web-based clearing house be created to gather and disseminate information on controversial topics from all interest groups without discrimination.** Such a platform could be managed by science journalists. In view of the flood of information and the range of interested parties, such a platform cannot be used to represent the "correct" perspective of the problem, but to raise the visibility of the plurality, in order to create a basis of understanding for a constructive dialogue.

(8) **acatech recommends that in addition to the proven models of communication and participation, new, innovative forms, in particular in relation to the new media (Web 2.0), are further tested, developedand evaluated.** For example, web-based communications could be used to identify interested young people, who could then exchange information in personal dialogue events. Those who organise communication and participation processes should be required by their sponsors to take on board scientific assistance in evaluating communication projects and undertaking methodologically sound assessments.

Recommendations to institutes of higher education

(9) **acatech recommends that training in basic skills for science communication (for specific target groups and based on facts) be integrated into higher education.** Students and graduates are key ambassadors for science. By obtaining their own, early experiences of communication, they will be able to reach more realistic assessments of the opportunities and challenges of scientific communication. Recommendations for practice and media training for scientists should be developed on the basis of practical experience and theoretical analysis. The objectives of training in communications as part of university degrees (basic course on science communication) should be that undergraduates and doctoral students are able to present their own work briefly and comprehensibly and register the social and political context of their work. Higher education institutions must also offer continuing training and basic courses on technology and science communications for those in the natural sciences and engineering.

Recommendations to science studies

(10) **acatech recommends that science studies be launched to systematically bring together the findings of theoretical research with practical experience.** Although many studies into the relationship between science, the public and the media already exist, there are no comparative studies based on empirical evidence in Europe or at an international level. These would form a prerequisite for the further development of science communication.

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