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Article

Making space for CRISPR: scientists' translation work to make gene editing a legitimate technology

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Abstract

This paper focuses on scientists working with CRISPR in Norway, where genetic modification is thought to be a particularly stigmatized technology with strict regulation and a strong consumer skepticism. Drawing on actor–network theory, we investigate the translation work these scientists perform to mobilize CRISPR as a more legitimate technology and how they relate to society's perception of GMO. We find that the scientists make co-productions of CRISPR as a 'more controllable' and 'socially useful' technology and show how they attempt to mobilize industry, farmers, media, politicians, and youth by (1) distinguishing CRISPR from GMO, (2) assuring the consumers of CRISPR's safety, and (3) creating trust through openness about the risks. We conclude that the scientists' efforts are twofold; they work on solving societal challenges, as well as making continuous efforts to manage their relationship to society. An important part of this work was seen as providing knowledge and creating 'new understandings' about CRISPR; however, if research should take place in conversation with society's views and opinions, we suggest that the scientists should enter into a two-way dialog with the consumers about these definitions.

Key words: CRISPR; gene editing; actor-network theory; biotechnology; governance; science policy.

1. Introduction

Genetically modified organisms (GMOs) have been followed by controversy since the 1990s, with heated and long-standing disagreement between scientists, politicians, industry, farmers, non-governmental organizations (NGOs), and consumers about the development of GMOs and the use of the associated techniques for production (Almås 1999b; Macnaghten 2015; Scott et al. 2018). The controversies have been related to the development and use of GMOs and the role of transnational companies promoting their market approval. The rejection of GMO among a range of actors and Europe's strict regulation of genetic modification techniques in agricultural biotechnology have fed the widespread view that genetic modification is a stigmatized technology (Hviid Nielsen 2007; Haukenes 2008; Magnus 2012), where not only the use of the technology but also advocating its prospects has been seen as difficult (Heggem 1999; Magnus 2000). In Norway, public conversation has tended toward a polarized debate where consumers have expressed concern for the disadvantages for the environment, human and animal health, and agriculture (Heggem 1999; Magnus 2000). A large opinion survey held by Norsk Gallup in 2006 reported that as many as 75 per cent of respondents rejected genetically modified food (Hviid Nielsen 2007), and this lack of public acceptance has halted both financial and political support for the research and development of GMOs. The public as consumers have consequently been granted much attention both implicitly and explicitly, and considerations for the underlying causes of consumer skepticism and the need to grant the consumer a freedom of choice (the freedom to NOT choose GMO) have been considered important arguments for why Norway carries one of Europe's most restrictive policies on GMOs (Magnus 2011). The consumer skepticism and the strict regulation of GMOs have in this sense been mutually co-producing factors that over the past 30 years have prevented the production and use of GMOs in Norway altogether. To this day, there are no GMO products on the Norwegian market: the only exception is a particular type of carnation.

While the Norwegian consumer skepticism to GMOs is widely studied, there has been little empirical research that focuses on how scientists working with the technology relate to this skepticism. In this paper, we build on the notion that Norwegian scientists who work with gene technology and GMOs find themselves working in a heated climate, with a technology that in some ways can be seen as illegitimate by Norwegian society. While research and development of GMOs has had low priority in Norway for the past 30 years, the scientific communities together with industry and producers are increasingly interested in harvesting the prospects and opportunities that second-generation gene-editing technologies, for example CRISPR, are thought to bring in food production. The public, on the other hand, has been found to remain skeptical and distinguish to very little degree between first-generation genetic modification technology and

gene-editing technology (Bugge and Grav Rosenberg 2017; Bugge 2020; The Norwegian Biotechnology Advisory Board 2020). The gap between the science community and the public in the question of willingness to use gene technology in food production has thus widened, and in order to bring the public along the scientists find themselves challenged to find new ways of translating their visions into consumer acceptance rather than skepticism in order to create room for gene-editing technology as a legitimate technology.

This article will investigate scientists' efforts to work with gene technology in this particularly heated climate. Using actor–network theory, we follow twelve scientists in their efforts to negotiate current and new understandings of GMO and CRISPR, and we ask: *how do the scientists address the consumer skepticism, and what translation work do they perform to establish a space for which they can use gene editing technology?*

The objective is to widen the knowledge of the scientists' role in the governance of gene-edited technology and provide a comprehensive picture of the dynamics and conditions under which GMO and gene-editing technology become accepted or rejected. By taking a closer look at the work they perform, both practical and cognitive, we can discover how they attempt to shape gene-editing technologies such as CRISPR as a regulatory and social object. Scientists working with CRISPR are central actors in these negotiations, and their research provides knowledge to scientific development, political decision-making, and shaping public opinion. Their work can be seen as efforts to build relationships with society, and by describing this practical work, we will also provide an understanding of how scientists manage the science–society relationship.

2. Situating gene-editing technology

The GMO controversy has given rise to a number of studies focusing on the dynamics and conditions for which society evaluates the technology (Macnaghten 2015; Binimelis and Ingeborg Myhr 2016; Hartley 2016; Wickson et al. 2017), and some of these studies have focused on the underlying reasons for lack of public acceptance. Analyzing a public opinion survey from 2006, Hviid Nielsen (2007) found widespread skepticism toward genetically modified food among the respondents but also noted a more optimistic attitude toward the notion of genetic modification in medical treatment where they believed that it could be of greater benefit and, therefore, more morally justifiable. Acceptance did not only depend on the technology itself but just as much on what the technology would be used for. In recent years, there have been three Norwegian surveys aimed at uncovering whether opinion has shifted: Consumption Research Norway (SIFO) (Bugge and Grav Rosenberg 2017) concluded that there was still considerable consumer skepticism in 2017, with more than half of the respondents, 53 per cent, expressing concern about the negative effects of genetic modification on nature/ecosystems and health (43 per cent) (Bugge and Grav Rosenberg 2017: 51). A follow-up survey performed by SIFO in 2020 aimed at identifying shifts in consumer attitudes but found that they to a large degree remained skeptical toward GMOs. The GENEInnovate-survey, also carried out in 2020, was the first public survey that also focused specifically on second-generation gene-editing techniques. The report concluded that the respondents were (more) positively disposed to gene editing provided that the purpose was socially beneficial and sustainable but still noted a significant concern: around 60 per cent of the respondents answered that they were slightly or very worried about gene-editing food due to potential negative consequences for health and the environment (The Norwegian Biotechnology Advisory Board 2020: 28), thus noting slightly more concern for the consequences for health and environment than the survey from 2017. Another interesting finding in this survey was that the consumer did not distinguish between the use of gene-editing technology and gene modification technology.

Since the dawn of CRISPR in the early 2000s, research efforts have been put toward understanding the conditions for public acceptance and the need for governance of new forms of gene-editing technology (Hartley et al. 2019; Hilgartner 2017b; Rose et al. 2020; Middelveld et al. 2023). These studies have showed how CRISPR is challenging the perceptions, regulations, and institutions that previously has controlled GMOs, and they have demonstrated how the regulation and perception of CRISPR even within Europe build upon distinct and conflicting co-productions of cultural and technical aspects and that CRISPR edited organisms in themselves are geopolitical objects (Meyer and Heimstädt 2019). This shows how CRISPR is a deeply politicized technology (Helliwell et al. 2017) and supports claims that the governance of it is performed both within and outside of formal governing institutions (Svingen 2023), including within the laboratory (Latour 1987). A systematic review of academic literature on reasons for and against the development and use of genome-editing technologies in animals by de Graeff et al. (2019) provide insight into the academic debate on gene-editing technology. In addition to finding a disjunction between the public and academic debate, de Graeff and colleagues note a lack of disciplinary diversity in the academic contributions (de Graeff et al. 2019). The focus on who is involved in the academic debate and thus helps to shape it underlines both the role that scientists play in the shaping of the governance of gene-editing technology and the important contribution this article plays in filling a knowledge gap from the social sciences on the conditions for which gene-editing technology is accepted or rejected. Investigating if and how scientists working with the technology attempt to take part in the politization of CRISPR thus becomes interesting in order to see how they attempt to make their knowledge accepted and validated in society.

Experiences from the GMO controversy have played an important part in shaping research policy and academic concepts that underpin the need for democratic involvement of societal actors, and their values and needs, in the research process (Owen et al. 2013). Gene-editing technology and CRISPR have therefore been widely understood as objects in particular need of democratic governance, both from within biotechnology communities (Sarewitz 2015; Doudna and Samuel 2017) and from critics within the Social Sciences (Jasanoff et al. 2015; Hilgartner 2017a). Policy demands such as 'Responsible Research and Innovation' (RRI) and academic ideas such as the need for 'democratic governance' (Owen et al. 2013; Stilgoe et al. 2013) and for creating 'socially robust knowledge' (Nowotny 2003) suggest that it is necessary for knowledge to be in dialog with actors outside of the university in order for it to be relevant. The responsibility of

science and society has been eminent in the RRI discourse and 'responsible' is a term frequently mentioned in debates about gene editing (Meyer 2022). Claims have been made that RRI as a policy demand has put responsibility for dealing with society within scientists' research practices, hence making the scientist responsible for performing responsible research (Åm et al. 2021). Von Schomberg (2015) goes as far as describing the failings to interact with stakeholder opinions in resolving conflicts as a form of 'irresponsible innovation', leading us to suggest that Norwegian scientists need to negotiate with the consumer skepticism in order to be seen as 'responsible' scientists. Nevertheless, the idea that knowledge development and research should take place in a conversation with society's views and opinions is widely established and suggests that the scientists need to be responsive to the consumer skepticism that has such a strong hold in Norwegian society in order to create knowledge that is robust, functioning, and accepted in society. Scott et al. (2018) suggest that the scientist can play a role in changing the skeptical consumer attitude toward CRISPR and GMOs, but how the scientists' face these attitudes are not well documented nor investigated.

From these studies, we draw a need to focus on the interrelationship between society and science and to pay attention to the translations of the knowledge that move between the actors in these spheres. Science and technology studies have generated numerous studies looking at the scientist 'in action' (Latour 1987), widening the understanding of the scientist as a knowledge broker (Pielke 2007) who actively work to establish his knowledge, his identity, and his responsibility in technological development (see, for instance, Jasanoff 2004; Borup et al. 2006). The actor–network theory looks at technological and scientific practices as a set of closely connected relationships between people and things (Latour 1993), and Latour suggested that we as social scientists should follow knowledge production as it move from scientific practice as something uncertain and debatable to scientific fact as something certain and indisputable (Latour and Woolgar 1979). To understand how the scientists work to create the 'room of possibilities' where the use of CRISPR can be realized, we find the actor–network theory to be a useful analytical tool.

3. Enabling the scientist

The purpose of studying *the relationship* between actors and actants was according to Latour and Callon to describe what enables people to act, all the aids, alliances, and mechanisms which are used, as well as how power is produced through the scientist's ability to 'move and displace' knowledge, in order to mobilize a functioning network of actors and actants who all pull toward the same goal as the scientist (Latour 1993; Callon 2001). The goal of our interviewed scientists is to work with CRISPR as a tool, but is it even possible to imagine in the current climate? The goal of the scientists seems somewhat of a quandary in itself: on the one hand, the scientists are strongly hampered by the strict regulation and consumer skepticism, unable to perform the research they want to carry out. On the other hand, they have a responsibility as researchers to be in dialog with society and take society's values and opinions into account when performing 'responsible research'. How do they entangle this quandary?

Our actor-network (ANT) analysis draws on the idea that in order for CRISPR to become accepted and stabilized as a legitimate technology in society, actors and actants need to act and negotiate with each other. Power, structures, artifacts, institutions, and nature are effects generated in the dependent network between these actors and actants (Law 1992). It is these connections that produce society, and it is they who must be analyzed if we are to understand the social world. Thus, ANT is used to investigate how the scientists work to realize the research they would like to do with CRISPR. The purpose is to discover how the scientists describe their efforts to make their research relevant to other actors, and how they see the other actors as relevant to their own work and the accomplishment of it. Our focus will be on studying the translation of knowledge (or attempt thereof) between the scientists and other actors (Skjølsvold 2015), where the status as actors is not only reserved for humans but include artifacts and things; actants can according to ANT also have agency and effects (ibid). What role do the non-human actants play in the scientists' network, and what power do they have? By investigating the everyday practices as described by the scientists, we can also reveal how power is distributed and what actors who gain leverage and power of definition in the network of actors. Callon (1984) argued that we could read what happened in this network as a translational process. Translation can be understood as the translation of ideas and interests, from one actor to another (Skjølsvold 2015), with the purpose to persuade others and gain traction for one's own understanding. What do our scientists do to convince other actors about their perceptions, ideas, and solutions?

Applying the concepts of Callon's Translation Process (Callon 1984), we have empirically investigated the scientists' translation work to capture interest and create credibility around their research and themselves as researchers. The translation is a process where the actors' identities, opportunities for interaction, and room for action are negotiated and delimited (Callon 2001: 97). Callon outlined four overlapping phases that made out the translation process, phases that are not described or used chronologically, but understood as efforts that overlap and intersect both in time and space:

'Problematization' is the phase where the scientists work to highlight a problem that needs to be solved and gain a common understanding among relevant actors (Callon 2001). The second phase is 'interessement', creating interest, which can be understood as an elaboration of the problematization. The actors need to be persuaded that it is in their interest to join the scientists' network and to support the scientists' knowledge and ideas. The third phase is 'enrolment', where roles and identities are attributed and accepted (Callon 2001). The actors negotiate and find strategies to define and intersect the different roles in the network, and together the actors build institutions and stabilize interest. In the final phase, 'mobilization', the network of actors is stabilized and made effective. Representative spokespersons are put in place to speak on behalf of the network and act as a 'united power' externally to ensure that claims are perceived as reliable and indisputable (Callon 2001). But Callon points out that consensus at any time can be challenged, 'from translation to treason it is but a little step' (Callon 2001: 117). New translations can lead actors away from their spokespersons and from the problematization, and the network may fail. Maintaining a network together will therefore involve continuous translation work. Following Callon, we will look at the scientists' translations

of CRISPR and investigate how they work to make CRISPR accepted and validated.

4. Following the scientists

In order to investigate the translational work of Norwegian scientists in the context of consumer GMO skepticism, we aimed at eliciting the scientists' own account of how they work, and attempt to work, with gene-editing technology in Norway today. Our empirical resource was defined as scientists in Norway who had knowledge of gene editing/CRISPR and who worked in fields where gene editing/CRISPR is relevant, and we sought out candidates by contacting various research institutions in different parts of the country. The scientists were strategically selected based on our expectations that their individual competency and practice could shed light on the research questions. These scientists belonged to fields dealing with human–medicine as well as fields within agriculture and food production (animals and plants). By recruiting interviewees who were dispersed geographically, institutionally, and topically, we aimed to obtain a diverse and representative sample that allows us to show examples of how scientists relate to the noted consumer skepticism. Out of twenty invited scientists, twelve accepted the invitation. The eight scientists who rejected the invitation did so for a number of different reasons, where time or their own research's relevance were the primary reasons. The twelve interviewed scientists were affiliated with Norwegian universities or research institutes, excluding representatives from industry (see Table 1 for informants).

Our choice of method for this investigation was partially structured qualitative research interviews carried out within the time frame 2020–2022. The interviews were primarily carried out digitally and lasted approximately 60 minutes. Authors 1 and 2 interviewed a total of twelve relevant scientists, and the interviews were designed to gather the scientists' own accounts of their scientific practices and how they worked to realize their research. The interviews were structured around open questions, and they were asked to deliberate on their perceptions of CRISPR and the technology's benefits and challenges in Norway, as well as their experiences with society and societal actors. The interviews were audio recorded and later transcribed. The interviews were also used as empirical data in a master thesis by Author 2 (Jahren 2022), and this article builds on some of the findings and analyses that emerged in this work.

Table 1. List of interviewees.

Informant	Position/Academic discipline	Gender
1/C	Professor/Natural Sciences	F
2/A	Researcher/Natural Sciences	F
3/D	Associate professor/Interdisciplinary	M
4/H	Professor/Humanities	M
5/K	Researcher/Natural Sciences	M
6/E	Postdoc/Social Sciences	F
7/F	Postdoc/Medicine	M
8/L	Researcher/Natural Sciences	M
9/B	Researcher/Interdisciplinary	F
10/J	Professor/Humanities	M
11/G	Associate professor/Medicine	F
12/M	Researcher/Natural Sciences	M

We approached the analysis of our transcribed interviews with a grounded theory development (Glaser and Anselm 1967; cf. Charmaz 2006) and coded them thematically using the Stepwise-Deductive Induction model (Tjora 2018) to extract the essence of the material and facilitate the ANT analysis according to Callons' translational phases. This allowed us to follow the scientists as they described their efforts to create room for working with gene-editing technology and CRISPR, which focus on the practical, cognitive and visionary work they addressed in the interviews. Through the accounts of their efforts and practices, we can unfold the network of actors that the scientists try to interest and enroll in their network in order to make CRISPR a valid and legitimate technology in society.

5. Empirical analysis: Co-producing CRISPR

The interviewed scientists did research in different fields and hence negotiated the use of CRISPR in different organisms and/or actors. Common for a majority of the scientists was that they had clear visions of CRISPR as a technology that enabled them to do novel and better research, by doing their research in a new or different way than before, or by doing research on new organisms and products. CRISPR was seen as more applicable than the older genetic modification techniques, and the possibility to show concrete and important solutions gave according to the scientists' reason to be optimistic. Scientist M had worked with issues concerning labeling and traceability of GMOs for over 20 years, and he described the industry as being more positive to CRISPR than GMOs:

> M: (…) now it is actually possible to talk about positive and useful products that are relevant to Norway, and where the industries themselves also help to communicate that 'yes', this is actually something we are seriously considering as a potentially useful product for us.

The OMEGA-3-rich algae that Scientist A wanted to produce with gene editing was seen as useful in increasing food production and reducing the pressure on nature, as it is both an important ingredient in fish feed, as well as being a scarce commodity that has a limiting effect on salmon aquaculture and its ability to expand and develop. According to scientist A, her microalgae could solve this problem and at the same time solve environmental issues. She was optimistic in accomplishing this, but also uncertain of the used potential. She had discussed the possibility of commercializing with actors from industry and commerce, but even though they were interested in what the gene edited micro algae could do for them, they were holding back:

> A: 'We had a meeting with the aquaculture industry, and they said they would be interested if the algae were not defined as GMO. They are scared to death of the GMO label. It could probably become legalized, but the industry doesn't want to be associated with GMO (…), they make profit on their product being pure and natural'.

The industry's concern for lack of consumer accept was standing in the way of realizing the potential of micro algae, both for solving the environmental issues and for the industry to reap the benefits. They were concerned with 'GMO

algae' coming in the way of the perception of the industry as pure and natural. As long as the consumers were negative, the marine farming industry would maintain a reluctant attitude, as the consumer and the marketing potential was their main concern. Similar issues met Scientist L in the agricultural industry, something he explained with the same fear of not gaining accept from the consumers. He also thought that the industry was forced to front an anti-CRISPR/GMO attitude to comply with the consumers' expected dismissal and feared the consequences for his own research:

> L: 'Graminor, which is the only processing company in Norway, is very enthusiastic about the technology. But every time they say something that supports it, they add": "but this is not something we do". And that's because they are afraid that consumers will connect them too strongly to the CRISPR technology. (…) There are no large companies that are interested in fronting it'.

The scientists had clear visions of how to use CRISPR to solve concrete problems related to food production and environmental issues, but they had difficulties with both the aquaculture industry and the agricultural industry and struggled to get them fully mobilized. We can say that they to some extents were enrolled as actors in the scientists' actor–network, but they were unwilling to work and speak on behalf of the network as long as the consumers were not on board—and as long as the products they made were determined and labeled as GMO. The scientists described similar challenges with their translation work toward food producers and farmers: on the one side they were willing to accept CRISPR as more technically acceptable than GMOs, seeing it more as a form of legal and uncontroversial breeding technique than to gene modification technology, but on the other hand, they were equally as concerned for the consumer skepticism as the industry was.

5.1 Negotiating the technical

The scientists' attempts to prove CRISPR as useful in solving concrete problems were somewhat successful with industry, and we can see that the scientists are able to 'interest' in a way that makes the industry an actor in their actor–network. Getting them working, ie. mobilizing them fully was however difficult without being able to enroll the consumers, too. Like we saw, Scientist A was sure that the fish farming industry actually was interested in her algae but were reluctant because they feared market reactions. Scientist L had the same problem with the food industry when he tried to persuade them about his gene-edited strawberries:

> L: 'What they care about is the consumers (..) But if you change the consumers' attitudes, then I think a lot of people would change their mind the same day. Because I think many people see the scientific reasoning behind it'.

Because the industry-consumer relationship seemed like a difficult entanglement to dissolve, the scientists found themselves struggling to find ways of getting the two actors on board because one was difficult to enroll without the other. The scientists were therefore looking for other ways to *interest* society in their knowledge. This involved negotiating the technical aspects of CRISPR, and Scientist H believed the difference between transgenic and cisgenic modification already made a difference also to actors outside of the scientific laboratories:

> H: '(…) to the extent that you ask people, (…) "do you want to eat a genetically modified salmon?" (…) people are mostly negative. But that's why gene editing is interesting. (…) Because it is considered something new, and when you ask people questions and explain the difference in the technologies and say "gene editing without adding foreign genetic material, could you imagine eating that?" Then the answer is much more nuanced and the room is bigger, and that's why both the industry and research is more interested in it'.

Scientist H described a 'room of possibilities' that had opened with CRISPR due to the technical difference between traditional GMOs and CRISPR based products. He stressed this point as vital in making other actors more positive toward CRISPR than they had been to GMOs, making the translation of knowledge on the technical aspects something that could further enable the societal change they envisioned; performing what we can call a form of social translation work. This had been helpful, he reckoned, in swaying researchers and the industry and making them more open to the possibilities of CRISPR. Several of the scientists described this translation work as central in creating space for working with CRISPR, and proving a technical distinction between GMOs and CRISPR edited products seemed vital also for Scientist L. In a research project using CRISPR to modify strawberries, he had tried to calculate for the established GMO skepticism by setting up an experiment which involved as little a change in the strawberry as possible:

> L: 'Normal GMO technology is about inserting genes (..) and it has been very controversial. While we chose a strategy that we thought was the least possibly controversial, by taking out a tiny bit, rather than putting something in. So the whole strategy from the start was to make the least possible intervention on the plant, so that if it worked, it would trigger the least possible resistance in the consumers, and everyone really'.

The strategy to make small changes was not only an attempt to accommodate the consumers' skepticism, but also in hopes of avoiding the strict GMO regulation. At the time the research project took place, the discussion on the definition of CRISPR and GMO was taking place in the EU (2018), and Scientist L hoped that EUs' conclusion would define products with small changes like the one they were doing, as non-GMO:

> L: 'When we started this, we made as few interventions as possible, so that we hopefully, should avoid GMO regulation. But then the European Court of Justice decided in twenty-eighteen that no matter how small or large a change you have made in the genetic material, then it will be defined as GMO. So that makes it a bit difficult'.

Negotiating the current Norwegian understanding was thus a main concern for him, and we see that the technical aspects were part of a scientific translation work. The

strict regulation of GMOs meant that his research was limited by this label, and the fact that the products were labeled as GMO by the regulation, had wider consequences for how the products were conceived by society. Scientist A was equally concerned with the regulation as she wanted to produce an OMEGA-3 rich algae, which in Norway would be considered a GMO, but in the USA, it would not be. The different regulation did not only hold practical consequences to the scientist, but also carried evidence that the algae she produced could be labeled and thus understood otherwise than it currently was in Norway.

> A: 'It's difficult for me to understand why there is a need for such a strict regulation on this (…) With the new technologies (…) one can actually make a gene modified irganism that does not contain any foreign DNA. (…) Is the algae a GMO or not? In the EU they're considered GMO because we use gene technology to make the mutant. But the algae won't be in the US, where you will be able to use it for anything, without restrictions'.

While Scientist L attempted to avoid the GMO label by creating small, cisgenic changes in the DNA, Scientist A put emphasis on the *precision* of CRISPR in her argumentation for the use of the technique. She considered CRISPR to be a more precise tool, and this was an argument that in her opinion should interest the consumers. Scientist A compared CRISPR to mutagenesis, which in her eyes was an uncontrollable technique in comparison. She was annoyed with the difference made between gene editing and mutagenesis in the current Norwegian gene technology Act, where the making of random mutations using radioactive radiation or chemicals (mutagenesis) was not regulated as GMO, while specific changes made with CRISPR was defined as GMO. Random mutations were in her opinion less safe than specific and controlled mutations, hence CRISPR was a safer tool than the widely applied mutagenesis.

Scientist C saw these examples of cisgenic use of CRISPR as a 'light version' of CRISPR which were primarily used and marketed because they were 'easy to sell'. She believed that scientists had tried to pave the way for CRISPR by putting emphasis on the possibility of knocking out a gene within the DNA, instead of making changes that required foreign DNA, transgenic modification. Scientist C believed that this version of gene editing was more easily accepted by the consumers and the industry, but it was not where she saw the most potential:

> C: 'What CRISPR (-scientists) has done in the beginning is trying to say that it has nothing to do with gene modification, and tried to say that the only thing we are doing here is something that could happen in nature, just knocking out a gene. But that's not the best part (of CRISPR). For example, if we want to make long marine fatty acids in plants, you cannot do it by knocking out a gene that is there. You have to insert a gene. And then it's like a GMO'.

We see that also Scientist C were concerned with the technical aspects, but unlike the other scientists, she did not try to negotiate CRISPR edited products as non-GMOs. Even though she believed that consumer accept was necessary, the solution to creating space for CRISPR was described as political rather than technical, and we can see that she made another coproduction of CRISPR than scientist H and L. She imagined that only a concrete product in line with consumers' own values and needs could help sway public opinion toward GMOs:

> C: 'So you probably just have to wait for, for example, an "Impossible Burger". Which can show that this (CRISPR) can mean that the ninety-five percent who are meat-eaters can replace some of their diet with plants. Which is much better for our planet. And that can only be done with genetic modification. It has happened in the United States. And there too, as in California, there has been some anti-GMO. But the impossible burger has made people say: ok, we get it and it's worth it'.

Scientist C's strategy was to interest the public in a solution that was considered important enough to out-weigh the perceived disadvantages of GMO. The vegetarian, CRISPR produced "impossible burger ", represented a sustainable and healthy lifestyle which she imagined the consumer to seek. She did not want to distinguish CRISPR from GMO like the others but considered it reasonable to expect that the consumers were willing to accept a certain amount of risk if the benefits supported their values, focusing on political rather than scientific aspects. In an ANT perspective, we can say that the impossible burger was more than an example of how CRISPR could be used, but also something scientist C had enrolled in her network as an actant—a non-human actor, and a helpful one that could help scientist C to persuade other actors toward accepting gene editing technology.

We see that the scientists focused on different technical and procedural aspects of the technology and had different thoughts about how they could distinguish CRISPR from GMO. It was evident that they all attempted to 'sell' CRISPR to the industry and that the selling points were the technical distinctions between gene editing technology and gene modification technology. Their translation work thus consisted of providing knowledge on the technical aspects of the technology, but as scientist C noted, the 'easy to sell' version of CRISPR would not necessarily be the version that was most useful to society in the long run. We can see that an important part of the attempts to build a network was defining gene editing technology, and that developing a rhetoric with which they could interest and mobilize actors was of essence. Nevertheless, the scientists saw industry as reluctant to join their network because the industry feared it could damage their own mobilization of the consumers. Therefore, the scientists also described the performance of translation work that was aimed at the consumers, where the technical aspects of CRISPR also played a major role in addressing the perceived skepticism among the consumers.

5.2 Responsible by control

CRISPR was described as a tool that the scientist felt they better could control, and they considered the precision it withheld as a vital argument for making the consumer more trusting toward CRISPR. The trust in CRISPR also meant trusting the scientists, who in this sense both enabled CRISPR and was enabled by using CRISPR (to fulfill their visions). CRISPR can be understood as an actant already enrolled in the scientists' network, and the fact that they had managed to enroll this 'awesome power' (Doudna and Samuel 2017) over nature and

the DNA was to many of the scientists a significant accomplishment in itself. But while CRISPR, by reputation and theory, was considered easy to use, enrolling CRISPR fully had demanded efforts from the scientist when they first started working with CRISPR, struggling to make the actant CRISPR interested in working toward the same goal as the scientist wanted:

> G: 'But in the beginning, we struggled a little bit. Everyone did, right? There were so many things one discovered, that these TAS9 didn't have very good reading glasses and went other places and you had to double check quite a lot'.

The scientists had been able to work a lot with CRISPR over time and get the technique under their control, but some scientist still saw problems in fully enrolling CRISPR for the purpose they wanted. One of the prime concerns were so-called off target effects: the possibility for the nuclease to cut other places than what was intended, again causing other changes than the scientists in the lab had set out to do. Scientist F underlined that the CRISPR technology had proved to be less specific than hoped:

> F: 'In my hands, as we say in the lab, CRISPR is not as specific as we had imagined. There is a lot of talk now about off-target effects'.

Being open about these off-target effects was described as an important task for the scientists, and they all wanted to make explicit the risk and felt insecurity concerning CRISPR. They stressed the importance of managing and minimizing these issues before any products could step into society, but also about being open about these risks and communicating them to the consumers:

> K: 'We've been pretty good at trying to talk about what we do. We have received a very clear perception that the most important thing we do is to be extremely open. No secrecy, you won't get anywhere with that'.

Scientist K thought that openness around his own research practice was something that would take him and CRISPR where he wanted through building trust between the consumers and himself, and between the consumer and CRISPR. 'Openness' was thus considered a mobilization strategy. A way to accomplish this was to present themselves as *responsible* researchers. For Scientist D, RRI was mentioned as a methodology that had put emphasize on responsible research practices:

> D: 'The challenge with CRISPR is that it goes so incredibly fast. It is a lot of work to make it work, you work fast, and with tunnel vision. I have interpreted RRI in this project as time and space to be able to "slow down" the science'.

While several of the scientists were concerned with time, Scientist D was the only one who advocated slowing down rather than speeding up the research process. By the fact that time was set aside for anticipation, they created more space for reflexivity in the research practice. Adopting tools from the RRI framework had been pushed forward through demands from the Research Council of Norway, and for the research institution Scientist H worked in it meant the involvement of external 'ethical experts' from other research institutions to deal with RRI, hence widening their network to also include actors that could serve as providers of 'the ethical'. Openness toward society was considered a welcome strategy to the scientists, and Scientist J emphasized the benefits of explicitly portraying concern:

> J: 'Considering the field has been so very much infected with visions and dystopias about what the result can be, it has also been natural for the scientist to think out loud about the need for regulation and keeping the breaks on. Either out of strategic reasons or genuine concern. But also, for the field to have trust, the scientist needs to plainly state that we think about those things too'.

The scientists considered it important to be open about off-target effects and presented themselves as responsible researchers who were safeguarding the potential risks. Building trust was clearly considered a strategic measure, and one that could convince the consumers that the scientists indeed were responsible adversaries who controlled the technology but also were open about it when they did not.

As we have seen, mobilizing to gain acceptance of CRISPR in society was considered vital for being able to use CRISPR in research, and they needed acceptance of the products that their research would lead to. We can say that the scientists did different co-productions (Jasanoff 2004) of the technical and the political aspects when advocating CRISPR, and that the different understandings relates both to different ways of applying the technology, but also to different ways of understanding the consumer skepticism. As noted, the scientists tried to distinguish CRISPR from genetic modification techniques by emphasizing the technical differences, but they also approached the consumer skepticism with a form of social translation work as they focused on the public discourse on GMOs.

5.3 New understandings

As shown, the scientists thought it important to reach out with new understandings, i.e. different understandings of Genetic Modification than those that followed 'the old GMO debate'. With a more nuanced and technically informed perception of Gene Modification, they hoped to change how CRISPR and hopefully also GMO was debated and thus perceived, as earlier noted. By reaching out with their knowledge, the scientists hoped to be able to enroll the consumers, and the scientists were looking for other actors that could help them get their network working toward creating a space where CRISPR was legitimate, as also shown in Jahren (2022). Scientist D had thoughts about how he as a scientist could approach the debate going forward to avoid ending up with the same polarization that had characterized the GMO debate, and considered it important to avoid debates with strong opposites and prevent actors taking strong-hold in so-called trench positions:

> D: 'It is very important to normalize the use of language when it comes to gene technology because there are so many strange associations one can make. Gene technology can be so many different things, so you must get used to nuancing the debate (..) People need to start dealing

with gene technology without being alarmed, and without having to associate it with the old GMO debate'.

Creating new understandings was important, but also difficult because the public, in their opinion, had very little knowledge about CRISPR. Scientist D described a need for media attention toward the purpose '(…) to normalize the acronym, what it means, what it is, and what it is not. (…) Most people have no idea what CRISPR is', he said.

He wanted to engage in dialog with consumers to create more involvement around the technology, and with more involvement, the consumers could perhaps be more easily enrolled. For this purpose, the media was an important actor to interest and enroll as a spokesperson for CRISPR, but mobilizing the media was seen as a struggle. The scientists were frustrated with the lack of media interest in CRISPR and their research:

C: 'For example, when I send articles to Aftenposten (one of the major national newspapers in Norway), they are usually positive and want it, and give input on how it can be changed and so on. But when I finish the chronicle, they just say: "unfortunately, it"s not generally interesting enough". (…) You try to make direct contact with journalists and NRK, but as a rule they don't bother, it's not important, it's not what makes money for them. When they even have advertising for Aftenposten that says that the most important thing for them is to create emotional reactions in people. GMOs are not quite there, or, in any case, not CRISPR'.

The scientists perceived Media as a difficult actor to even interest, and they were frustrated with the media for only mediating polarized debates and for not being interested in conveying information unless it was sensational or emotional enough. Over the past years, it has been pointed out that media coverage of innovative technology is characterized by sensation-oriented narratives (Brown and Michael 2003; Gardner et al. 2015; Hilgartner 2015). This was problematic for the scientists just as they were actively attempting to move away from the sensational and polarized, and toward the more nuanced debate that Scientist D described. According to Gardner et al. (2015), so-called expectation gaps can arise between the so-called success narratives, and the more sober perspectives on what will be possible to achieve. Scientist C saw dire consequences of CRISPR being too little polarized:

C: 'The advantage, let me call it that, of there being a big GMO uproar was that you got more media coverage, because then there was interest in it. But since CRISPR came along, the anti-GMO-voices have become very quiet. There are no hard fronts and not much attention anymore. Then there's in some sense nothing to discuss'.

In order to achieve the interessement of desired actors Scientist G had taken matters into her own hands and sought to 'mediate' CRISPR and it's possibilities through the screening of a movie:

G: "I was a driving force to get this film [Human nature] to Norway. We showed it in Bergen, together with the BIFF film festival, but also at the cinema in Oslo, in collaboration with the Norwegian Biotechnology Advisory Board and the University of Oslo. So I have one hobby that is community involvement. I call it a hobby because, well, disseminating research, the idea is two-fold. One is that we are paid by the state and must give something back. The second thought is that I want to promote interest for research and getting more students to choose science, and that direction, and perhaps research" she said.

The film that informant G mentions is the science documentary Human Nature, which she had worked to make it known to the general Norwegian public. In connection with the film being shown, there was also organized a panel debate with discussion around practical and moral issues linked to gene editing (The Norwegian Biotechnology Advisory Board 2019). The aim of both the film screening and the panel debate was to create 'interest' and "enlightenment" of the problems which gene editing technology could solve.

5.4 Looking for other actors

Attention toward the CRISPR technology was described as lacking, not just from media but also from other relevant actors. Scientists expressed the need for more actors to be ambassadors for CRISPR, who could communicate more clearly that there was a need for gene editing in Norway. The Scientists had visions of how CRISPR could solve concrete societal challenges, but the realization depended on political endorsement of the Gene Editing Technologies. They considered the enrollment of the politicians as vital in terms of changing the regulation, which in turn was considered key for creating legitimacy for the use of CRISPR. Enrolling the politicians was a way to mobilize the regulation as an actant that would stabilize the network, yet getting the politicians even interested looked difficult. Scientist C thought it was because the politicians did not know enough about CRISPR and therefore did not understand why they should be interested in this technology:

C: '(…) when you also see that the politicians in the Parliament know very little about it, then it's not that easy [to get them interested]'.

The researchers perceived the politicians as rather disinterested and difficult to engage in dialog with, and the scientists were disappointed in the lack of interest and knowledge among the politicians. They did however have reason to hope that something might be changing:

L: 'What the Norwegian Biotechnology Advisory Board initiated, this softening, it has meant that the Norwegian authorities have gradually taken it more to heart and launched the NOU. It has paved the way for a change. It is of course something that must be decided by the politicians in the end, but there is anyway a process underway'.

The process which scientist L referred to had demonstrated that The Norwegian Biotechnology Advisory Board (The Board) were positive to a relaxation of the regulation of GMOs and CRISPR (The Norwegian Biotechnology Advisory Board, 2018), and The Board had managed to interest an actor that the scientists had not: the politicians. The scientists saw The Board as a potential ally, and someone who

could help the scientists pull the network in the direction they wanted: toward changing the regulation and the consumer acceptance. It has been pointed out in previous research that The Norwegian Biotechnology Advisory Board is by many actors (science communities, industry, environmental NGOs, government administration and farmers) thought to be the actor who controls the Norwegian debate on GMOs (Magnus 2011), and we see that this to some extent is confirmed by our interviewed scientists. Having such a 'powerful' actor as an ally was important to the scientists as it allowed them to move toward a 'working' network, and strengthened the prospects of enrolling also other actors on the rhetoric where the degree of genetic intervention was determinative.

The Board was an actor that several of the scientists had sought to cooperate with, taking part in public debates organized by The Board and contributed with their scientific knowledge in dissemination activities in high school:

> D: '[We] have been in different classrooms with high school students and have talked about CRISPR and had role plays about research and industry collaboration, and ethical dilemmas and how to think about values in the ethical situation around CRISPR. Getting out into classrooms, and into rooms with art, to bring about slightly broader dialogs, I think that is an important strategy to have'.

The visits were set up as learning activities, but the focus was also on another effect: to create interest in CRISPR and what the research with CRISPR could accomplish. Involvement entailed a repertoire of different ways of engaging, and in addition to making school visits, the researchers also invited the students to 'their homes', the laboratory. Scientist D gave an example from her research project:

> D: 'It is very exciting for them to see a local application of the technology with the sterile salmon (..) where, among other things, they get to see the crisperization of eggs. It is very positive, but it is not these students who will soften the laws'.

The researchers' dissemination work toward the schools was clearly an enrollment strategy and allowed them to enact the dialogs they had wanted in order to create 'new understandings', and the scientists were keen about the positive attitude they encountered:

> K: 'Both myself and others have been out and talked a lot about this technology. We have been to schools, with workshops and different things, and we have also made a questionnaire that we had a school test out. And then we saw that it is the elderly who is most skeptical, while the younger they are more open, especially if we asked questions like: "would you like to eat and are you positive towards gene-edited salmon on the condition that it will help protect our wild (salmon) populations?". Then we got one overwhelming "yes!"'.

The high school students were not considered predisposed by the old GMO debates and were described as enthusiastic about science in general. They also demonstrated a great deal of trust in scientists within the field of gene technology (see Levold 2021). Scientist Ks experiences showed that the high school students were willing to let themselves be enrolled into the actor–network, and he suggested that as future legislators it was a good starting point for a more permissive regulation.

5.5 Something at stake

Scientists K and G were optimistic about the enrollment of the youth in their network but, as we have seen, interesting and enrolling the media, the politicians, and the consumer was expressed as equally difficult to the scientists. Finding a problem that was important enough for the consumers to care about was problematic, and the scientists reflected on how they could show the consumers that CRISPR was of interest. Scientist J believed that most people did not understand how CRISPR was relevant to them; they did not see what was at stake and what the problem was. It thus gave little reason to be interested:

> J: '(…) There has to be something at stake. And that's probably my feeling with CRISPR, that it takes a bit to ensure that it really catches on in society'.

She therefore saw it as an important job as a researcher to show how CRISPR was relevant and useful to them. The scientists described CRISPR as a tool that enabled them to contribute with solutions to concrete problems which they reckoned we face as a society today. These challenges were also seen as a tool to onboard the consumers as the scientists saw societal challenges as something that could persuade them of CRISPR's relevance:

> M: 'The man and woman on the street do not relate, you might say, to the large research projects that have looked for whether something is dangerous. They relate primarily to "do I think this is useful for me and for our society and in what way?" (..) We have some real issues, like potato production for example, where pesticides are used today, right, and where we know we can, we can make some pretty significant changes, same with strawberries. So we can reduce pesticide use in Norway, we can significantly reduce crop losses in Norway. Then people start to think "yes, but it's okay, it's good"'.

Scientist M thought that the consumers could be swayed if the scientists were able to demonstrate the *usefulness* of CRISPR. The interviewees lifted several future challenges that in their eyes could be solved by using the CRISPR technology and communicating these solutions to society were seen as key in interesting the consumers to join the scientists' network.

Scientist L made efforts to problematize and described the constant population growth as the primary challenge facing todays' society. She saw the fast increase in the worlds' population as a cause for an ever-increasing need for food, and an ever-increasing pressure on nature. She was particularly concerned with food production and Norway's lack of food security in the future. Climate changes and more wet weather was one of the issues they thought stood in the way of becoming more self-supplied within food production:

> L: 'The greatest problems are simply loss of crops for the farmers, that the farmers risk losing almost all of their

produce. If you can prevent it by the help of gene technology, then that would be amazing. That is the primary motivation for choosing to work with this'.

Through sharing her visions for the usefulness of CRISPR in solving both environmental issues and food security, the scientist tried to 'problematize' and show how their research and CRISPR should be interesting to society. She experienced however that the consumer did not always agree with the scientists' perception of CRISPR as a solution, nor what problems we face as a society. Consumer-oriented NGOs like The GMO Network in Norway engaged in the debate on food supply, arguing that the problem of securing enough food is not food *scarcity*, but rather a question of *distribution* of food between rich and poor countries. Scientist C saw this as turning the problem upside down, and the argumentation around the 'distribution issue' made no sense to her. Food safety and the access to food could be secured either by producing our own food or by importing it, she believed, and a more just distribution of the food already produced, could be helped by producing more food in Norway. Norwegians (consumers) also had the wrong impression of their own food supply, she thought:

C: 'We think the problem is over-production, but this is totally wrong. (…) In Europe we import more food year by year and become more and more dependent on importing food. (…) I believe people think that we produce too much food in Norway, but that is a fallacy that we should inform about"'.

Scientist C perceived negotiations with the consumer as halted by the disagreement on whether food safety actually was considered a problem. If the consumers did not know that Norway was facing a problem with food production, it was not easy to launch CRISPR as the solution to it. In order to get the consumers on board, it was necessary to create a common understanding about the problems we face as a society and which CRISPR could be the solution to. Scientist Cs' strategy was to try to fill the knowledge gap she perceived the public to have. To succeed in the problematization, she wanted to contribute with more information to the consumers about food security as an actual problem. The job of assembling the 'room of possibilities' where she could fulfill her visions seemed clear to her: first society had to agree with science on what the problem was, and then she could start interesting them in her solutions and successfully enroll the consumers as actors.

5.6 Making CRISPR legitimate

Throughout the analysis we have seen how the scientists work to translate their knowledge and visions to consumers, media, politicians, farmers and industry. Enrolling these actors into their actor–network was seen as vital in order to realize the work they want to do with Gene Editing Technologies, and we can say that the scientists' efforts to establish a space for which they can use CRISPR meant making CRISPR legitimate, both formally: through changing the legislation and creating research opportunities through funding, and informally: as an accepted technology by consumers and in society. These two aspects were however closely intertwined and not easily entangled. As we noted, the food industry and farmers were positive to the technical translation work offered by the scientists, but the social aspect and the consumer skepticism stood in the way of mobilizing these actors as part of their network; the industry and farmers were not yet advocates for making CRISPR legitimate. As noted, an important part of the translational work was developing and paving way for a specific understanding of gene editing technology. Gaining traction for this rhetoric would mean enrolling other actors on the understandings of gene editing technology which their particular rhetoric pushed forward. The work to build and establish this rhetoric was thus an important part of building their actor–network.

6. Discussion

In this paper, we have seen how the scientists attempted to build an effective actor–network to create a legitimate room for CRISPR in Norway. The scientists' actor–network was being built upon two particular co-productions of 1: CRISPR's controllability (the technical and processual distinctions between Gene Edited Organisms and GMOs), and 2: the societal usefulness of CRISPR. Both these aspects were translated practically (indirectly) and communicatively (explicitly), as they were incorporated in the scientists' research practices and projects, as well as explicitly communicated to society, as strategic responses to the experienced or feared consumer skepticism. Industry and farmers were the primary actors whom the scientists attempted to enroll into their actor–network, but these actors were found to be reluctant as long as CRISPR was associated with GMO. To the scientists, this meant performing translation work that revolved around 1: distinguishing CRISPR from GMO, 2: assuring the consumers of CRISPR's safety, and 3: creating trust through openness about the risks. Ideally, the scientists wanted the consumers to see CRISPR as something different than GMO, and they wanted to demonstrate the level of control they had with CRISPR. The scientists had a clear idea that the technical distinctions between genetic modification techniques and gene editing techniques was reason for minimizing the felt skepticism among the consumers, either due to precision or to the type of intervention (cisgenic rather than transgenic). The scientists explained how they had attempted to address this by calculating for the consumer skepticism when planning their research projects, choosing to focus research projects on products with small, cisgenic and 'easy to sell' changes to the DNA. Their efforts thus seemed two-fold, as they worked on solving societal challenges, as well as making continuous efforts to manage their relationship to society. An important part of the latter was seen as providing knowledge about gene editing technology and creating 'new understandings' through more and 'correct' knowledge about what CRISPR was: how it differed from GMOs and how they tackled safety and risks. This co-production of CRISPR's controllability was useful in interesting and enrolling the industry (yet not mobilizing them fully), but the scientists found neither the media nor politicians to be interested in pulling toward the legitimization of CRISPR on these premises. To reach these actors, and even more importantly, the consumers, the co-production of CRISPR's societal usefulness was thought to be a more successful strategy.

6.1 CRISPR's usefulness

CRISPR's societal usefulness was in the same lines as 'controllability' something the scientists perceived as a game changer. CRISPR was seen as more applicable than the older genetic modification techniques, and the possibility to show concrete and important solutions gave reason to be optimistic. Finding a problem that was important enough for the consumers to care about was however considered problematic, and the scientists reflected on how they could show the consumers that CRISPR was of interest. According to the scientists, industry was already interested and saw the potential that CRISPR had for future use, but they were unwilling to be fully enrolled, or at least not ready to be put to work as long as the consumers were reluctant.

The scientists' focus on usefulness can be understood as a way of addressing the consumer skepticism because, as noted, research has shown that the consumer skepticism toward GMOs is rooted in different framings of both problems and solutions. The scientists' strategies to explicitly 'problematize' with issues they considered relevant and important to society, and by offering solutions to these problems, can in some respect be considered a response to 'society speaking back to science' where the consumers' skepticism is considered a contestation of the scientific framings.

We would however like to note that the focus on usefulness also can be considered a political influence. Research is the scientists' livelihood, and therefore just as much under the influence of the research political climate surrounding them as they are affected by consumer skepticism and the climate spurred by GMO controversy. So-called mission-oriented research policies are permeating research funding programs like never before, exemplified by the focus on 'main missions' in the EU Horizon 2020 Program, where research is focused on responding to major societal challenges, also referred to as 'grand challenges' (Mazzucato 2018). This implies that research funding builds to a great extent on the idea that research should contribute to solving defined problems we face as a society, something the scientists' focus on usefulness is a good example of. Usefulness can thus be understood as useful to the scientists in at least two ways: 1: as a means of creating room for the use of CRISPR in Norway, and 2: as a strategic notion to mobilize research funding. Either way, the term 'usefulness', or rather the way it is understood, can in an ANT perspective be understood as a mobilized actant in the scientists' network which suggest that concepts and ideas can be useful to mobilize actor–networks in todays' research climate.

Whether or not the scientists will be successful in mobilizing their network and setting it to work will remain an unanswered question for now but looking forward the scientists did feel hopeful. Part of this hope lay in the successful enrollment of the 'consumers of the future'; the high school students. High school students were articulated as a starting point of something new, pointing to a group of actors whom also surveys have proven to be more positive toward gene editing technology. We can say that the scientists succeeded in mobilizing the students in their network, as the students: 1. accepted the problematization that the scientists had presented them with (we need to save the wild salmon), 2: let themselves be 'interested' in the solution they offered (gene edit the farmed salmon), and 3: accepting the identity as GMO-positive actors (through the questionnaire). We offer yet another perspective: that a reason for why the students were more easily enrolled is the distribution of power in the relationship between the students and the scientists. As has been made evident by this analysis, the consumer holds a great deal of power over the use of GMOs in Norway, and despite all the scientists' efforts, they must be considered the obligatory passage point for which the other actors: scientists, industry, politicians and even CRISPR, must gain acceptance from. It can be expected that in the 'teacher-student' relationship, the scientists hold more power than the students, and the classroom facilitates knowledge transfer in a more top-down manner.

The engagement with the high school students can be understood as the form of knowledge transfer that the scientists described, and perhaps something they ideally would like to extend to society as a whole. By filling the knowledge gap they describe society as having; among consumers, media, politicians and industry, the scientists want to create new understandings, both scientific and political understandings and most importantly effective co-productions of these. While creating new understandings can be a fruitful approach, we do ask whose understandings these should be? Through our interviews we understand the scientists' as wanting to 'push' their visions and knowledge on to the consumers, resulting in a top-down knowledge transfer. This is problematic as there is broad consensus that societal dialog entails a two-way conversation and the exchange of knowledge between society and science. However, the scientists are not attempting to grasp the cause of the consumer skepticism, and several of them talk about skepticism as something unreasonable and unjustified. Additionally, their strategies to face the consumer skepticism is based upon mere perceptions of what this skepticism originates from and does not address the issues which the consumer has been found to be most concerned for, such as the long-term consequences to nature and the ecosystem, and to human and animal health. If research should take place in conversation with society's views and opinions, the focus on usefulness and benefits needs to be complimented with addressing these consumer concerns in more deliberate and structured ways which seeks to grasp the complexity of consumer attitudes. Instead of offering their own, ready-made problematization and solution, we suggest that the scientists should enter into dialog with the consumers about these definitions. Also, we believe that more and detailed qualitative studies of consumer perceptions of these technologies is needed to compliment the quantitative public surveys in order to grasp the full dynamics and balance between acceptance and rejection. Finally, we suggest that governance institutions such as The Norwegian Biotechnology Advisory Board should seek to facilitate more direct links between the scientists working with the technology and the members of the public whom it affects as a means of bridging the gap between academic and public perceptions of gene editing technology.

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Data availability

The data can be made available on reasonable request to the corresponding author.

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