Rathenau Instituut

Welcome to the baby shower

How citizens talk about the synthetic cell

Report

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Visitors to Dutch Design Week are welcomed to a fictional baby shower for a synthetic cell. Photo: Laura Marienus/Rathenau Instituut

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Preface

‘Welcome to the baby shower’. That’s how we started our conversations with visitors to Dutch Design Week at our art installation about synthetic cells. The combination of an empty crib and a test tube containing candied anise seeds with pink, blue or white sugar coating – a delicacy eaten in the Netherlands to celebrate the birth of a child – turned out to be a perfect icebreaker. In nine days we had more than a thousand conversations with citizens about what they think about artificially creating cells.

But you might think: not everyone can have an opinion about this, because citizens know far too little about this technology to be able to talk about it, right?

That is a misconception. People can, after some explanation, talk about unknown technologies perfectly well. We at the Rathenau Instituut have known this for a long time, because we are specialised in conducting dialogues about science and technology.

In this report we analyse the conversations with visitors to Dutch Design Week. We see that citizens often fall back on primeval stories, so-called arche-narratives. One well-known narrative is ‘Pandora’s box’. This is about the concern that radical scientific interventions can bring unforeseen dangers and risks.

The beauty of the narratives is that they contain norms and values. Using these norms, and especially the values, researchers, funders and policymakers can ensure that synthetic cell technology develops in a socially responsible way.

Our research during Dutch Design Week is of course just a start. It is important to broaden the social and political debate on synthetic cell technology. In this way, society can shape the technology based on cultural, moral and public values. And in this way, a technology is born that is valuable to society.

Prof. dr. ir. Eefje Cuppen
Director Rathenau Instituut

Summary

This report is about how citizens view future synthetic cells. What stories or narratives do they use? What do they find important?

Synthetic cells could potentially contribute to solutions for societal problems. Think of genetically modified algae that make biofuels, or cells that produce medicines. But dangerous micro-organisms can also be developed. The synthetic cell therefore raises ethical questions.

In order to develop technology that is valuable to society, it is important to include the wishes, demands, needs and conditions of citizens at an early stage. However, synthetic biology is a relatively unknown field for the general public. This makes it difficult to initiate a societal conversation. That is why the Rathenau Instituut, in collaboration with designer Mies Loogman, has designed an artistic installation that serves as a conversation starter.

The installation was exhibited at Dutch Design Week in 2021. Over nine days, researchers from the Rathenau Instituut and others spoke to a thousand visitors. We recorded and analysed about a hundred conversations. This report shows how the interviewed visitors think about the social implications of synthetic cell technology and how they think this development can be guided.

Narratives about technology
In order to gain insight into how citizens' opinions about new technologies such as the synthetic cell arise, and which cultural and moral values underlie this, we used so-called narratives. The starting point is that citizens use narratives to give meaning to new technologies. Every culture has its own archetypical narratives in the form of, for example, myths or religious visions.

In this report we focus on narratives about technology in European culture. We distinguish between narratives about the social implications of technology and about the societal steering of technology (technology governance). Narratives about the implications of technology are for example, 'Believe in progress' and 'Be careful what you wish for'. Examples of narratives about the governance of technology are 'Stimulating innovation for economic growth' and 'Stimulating innovation for societal goals'.

We first tested the theory that citizens use narratives to give meaning to new technological developments by means of literature study. After finding support for this theory we used the narrative method to analyze about a hundred conversations about the synthetic cell.

In conversation about the synthetic cell
Our conversations during Dutch Design Week offer a first glimpse into citizens' views on synthetic cell technology. Visitors hope in particular that the synthetic cell will contribute to medical and climate solutions. But they have several concerns. One concern is that a strong focus on risks will undermine social progress. In addition, there are concerns about the ethical implications of making life, the uncontrollability of a technology that is literally alive, and the question of who ultimately has power over the technology and its development.

Most of the visitors interviewed believe that scientists in particular bear responsibility for the responsible development of technology. According to the visitors, scientists should involve other disciplines, interact with citizens, and adopt a critical, careful and open attitude during their work. The interviewed visitors also see a role for the government. The government is seen as a funder and facilitator of responsible research, whose role stimulates interdisciplinary collaboration and makes laws that anticipate unintended consequences.

Important values regarding the synthetic cell
The analysis of the conversations at Dutch Design Week shows that the issues that citizens raise are rooted in six archetypal narratives about technology in European culture. This provides a basis for how the social and political debate about synthetic cell technology can be conducted more broadly.

We identify eight values within the expectations of the visitors to Dutch Design Week:

1. Sustainability: how do we ensure that the development of synthetic cell technology contributes to a more sustainable society?
2. Health: how do we ensure that the development of synthetic cell technology contributes to a healthier society?
3. Innovation: how do we weigh opportunities versus risks? How do we prevent our focus on the risks of synthetic cell technology from hindering innovation?
4. Ethical limits: what are people allowed to do in relation to (adapting) nature? Shouldn't humanity leave nature as it is? How do we prevent the pursuit of perfection from becoming the goal of innovation?
5. Control (of the technology): How does society maintain control over a living technology like the synthetic cell? Do we want to release something artificial

or synthetic like the synthetic cell into nature? How do we prevent the synthetic cell from becoming rampant?
6. Control (of the technological development process): how does society monitor the development and application of synthetic cell technology? How do we prevent the technology from falling into the wrong hands?
7. Transparency and inclusiveness: who has access to the development of synthetic cell technology? Who can participate in decisions about this?
8. Equality: who bears the costs and benefits of synthetic cell technology? Who can and may ultimately use the applications of the synthetic cell?

Governance of synthetic cell technology

Our study shows that interviewed visitors to Dutch Design Week have a range of expectations and are concerned to varying degrees about the social implications of synthetic cell technology. Nevertheless, visitors are highly consistent about how the governance of this technology should be organised. Advice from visitors about the societal steering of technology fits well with three of the four governance narratives: innovation for societal goals, democratisation of innovation, and regulation and institutionalisation of innovation. The fourth governance narrative, ‘Stimulating innovation for economic growth’, is not mentioned by the visitors. This is striking because this is precisely the dominant approach of Dutch innovation policy.

With regard to *innovation for societal goals*, the interviewed visitors would like to see innovation contribute to resolving societal challenges and achieving public goals. For the synthetic cell, visitors to Dutch Design Week see value in solutions for good healthcare and sustainability. But this raises the question of how scientific research – and in particular research into the synthetic cell – can be structured in such a way that the results do indeed contribute to societal goals. The principles of socially responsible innovation can serve as a guideline here.

Regarding *democratisation*, visitors to Dutch Design Week want citizens to have an influence on the development of the synthetic cell. First of all, citizens believe that scientists and other technology developers have the responsibility to sufficiently consider the safety and social aspects of the technology. They believe that technology developers must involve a diverse group of experts, stakeholders and/or citizens in a timely manner and make knowledge about the technology public and accessible. Furthermore, visitors believe the government should anticipate new developments by organising social dialogues. For example, the government can explore ethical boundaries in consultation with various experts and stakeholders and then actually set boundaries. In addition, the government can, in consultation with researchers, experts and citizens, determine what the right direction is for the development of technology. The government must also, after consultation, indicate where the boundary lies in what is permitted to be researched and developed.

The narrative *regulation and institutionalisation of innovation* indicates that new laws and regulations can be developed if more knowledge is available about the safety risks and ethical questions surrounding the synthetic cell. The visitors to Dutch Design Week therefore see a role for the government as a supervisor of social innovation that anticipates new developments with laws and regulations. The government must ensure that safety is assured, ethical boundaries are not exceeded, prevent technology from falling into the wrong hands and ensure that access to technology is distributed equally across society.

Synthetic cell technology for society

The insights in this report show how citizens' expectations for a new technology are intertwined with their experiences and vision of the development of other technologies. It shows that citizens (in this case visitors to Dutch Design Week) are perfectly capable of giving meaning to a technology that is unknown to them.

The interviewed visitors are neither for nor against synthetic cell technology, but see both opportunities and risks. They believe that both the purpose for which and the way in which a technology is developed determines the impact a technology will have on society.

Our study shows that visitors to Dutch Design Week particularly want the government to stimulate innovation for social goals and to pay attention to the social embedding of innovation. And they do not want innovation policy to be primarily aimed at stimulating the economy, as previous and current policy mainly does.

Table of contents

Introduction

Synthetic biologists strive to gain control over the fundamental building blocks of life. They explore and unravel genetic material and components of living beings (organisms) and try to develop new biological systems with this knowledge (Rathenau Instituut, 2012). Some researchers are even committed to creating artificial life in the form of a synthetic cell. Newly designed organisms could contribute to solutions to social problems. Think of creating genetically modified algae that can produce biofuels or new medicines. But at the same time, potentially dangerous micro-organisms can be created. The various developments in synthetic biology therefore also raise ethical questions (Rerimassie, 2023).

How can we ensure that synthetic biology does what society both needs and finds ethically desirable? The *Future Panel on Synthetic Life* believes it is important to involve a broad group of political and social actors at an early stage in the development of a new technology. By making it a joint undertaking, the research could better respond to concerns and expectations in society (Aarts et al., 2022).

Involving citizens specifically is seen as an important condition for developing socially responsible technologies (Stilgoe et al., 2013; Bauer & Bogner, 2020; Aarts et al., 2022). In order to develop technology that is valuable for society as a whole, it is important to include the wishes, requirements and needs of citizens in the development process from the very beginning. By entering into discussions with citizens at an early stage, citizens gain insight into what is happening in the domain of science and technology. This interaction gives researchers insight into which issues are important to citizens and which conditions they set for the responsible development of technology. Involving citizens can thus contribute to the *democratisation* of science and technology (Fuchs et al., 2023).

Compared to other developments in biotechnology, synthetic biology is a relatively unknown field for the general public and is therefore little discussed outside scientific and political spheres (Akin et al., 2017). The conversation about synthetic biology is still small-scale in the Netherlands and little is known about how citizens think about this technology and what conditions they would set for its development.

In synthetic biology, a distinction is made between a top-down and a bottom-up approach. In a top-down approach, living cells are genetically and metabolically modified with the aim of introducing new functions. An example of this is the creation of a minimal cell. This is an existing cell that has been modified in such a

way that it only contains the absolute minimum of genetic information necessary for survival.

Bottom-up synthetic biology, on the other hand, is about creating cells from molecular components (natural or non-natural/synthetic). This type of research is conducted within the Dutch research programme *Building a Synthetic Cell* (BaSyC). By means of biomolecular building blocks, BaSyC researchers try to create an autonomous, self-sufficient cell that can grow and reproduce (Aarts et al., 2022). In addition, the Dutch government will invest in the EVOLF project in the coming years, which also includes research into the development of a synthetic cell.[1]

Since 2006, the Rathenau Instituut has been investigating the societal aspects of synthetic biology (see, among others, Rathenau Instituut, 2007; Rathenau Instituut, 2012). In recent years, attention has been paid to the societal issues that may be related to the development of synthetic cell technology. For example, the Rathenau Instituut, together with Radboud University, organised a *Future Panel on Synthetic Life* as part of the BaSyC research programme. The aim of this panel was to draw up an initial agenda for a political, societal and scientific debate on the synthetic cell. The most important discussion points, insights, challenges and dilemmas that the *Future Panel on Synthetic Life* identified have been published in a position paper (Aarts et al., 2022).

In addition, the Rathenau Instituut, in collaboration with designer Mies Loogman, produced a podcast series (in Dutch) about the development of the synthetic cell and the various questions that arise from this.[2]

The synthetic cell raises various ethical and social questions. Consider the tension between the unnatural nature of this technology and opportunities for health care and the environment, or the question of whether we are ‘playing God’ with this development (Rathenau Instituut, 2012).

1 https://www.nwo.nl/en/news/from-quantum-to-climate-five-teams-of-top-scientists-receive-summit-grant
2 https://www.rathenau.nl/nl/gezondheid/aflevering-1-van-herschept-een-podcast-over-de-synthetische-cel

Figure 1. Researchers talk to visitors at Dutch Design Week about the synthetic cell. Photo: Rathenau Instituut.

In order to stimulate societal dialogue about the synthetic cell, the Rathenau Instituut, in collaboration with designer Mies Loogman, conducted conversations with visitors to Dutch Design Week (DDW) in 2021. A physical installation was designed for this purpose. This artistic installation served as a conversation starter to discuss life with or without the synthetic cell with visitors, and thus gain insight into the reactions of citizens to this new technology. This report analyses, among other things, the conversations at Dutch Design Week. Appendix 1 contains more information about the installation and the conversations.

Research objective and approach

In the fall of 2021, we spent nine days talking to about a thousand visitors to Dutch Design Week about their wishes and concerns regarding the future synthetic cell, and their advice for the government and researchers involved. An installation (see figure 2) and a card with questions served as a conversation starter.

Of those thousand conversations at Dutch Design Week, about a hundred were recorded and analysed. This report maps how those interviewed visitors think about synthetic cell technology. How do they view the social consequences (opportunities

and risks) of this technology and in what ways do they think the technology should be governed? Which narratives play a role for visitors to Dutch Design Week in assessing the development of synthetic cell technology?

To answer these questions, a so-called narrative method was used. We distinguish between two types of narratives: narratives about the societal implications of technology, and narratives about ways in which the development of technology can be governed – so-called governance narratives. The narrative method assumes that people understand and judge technology on the basis of stories – or narratives. We tested this assumption by investigating whether the narratives about the implications of technology and the governance narratives that we find in the literature also occur in studies of the perspectives of European citizens on the development of synthetic biology and new technologies.

Figure 2. Artistic installation about the synthetic cell at Dutch Design Week 2021. Photo: Rathenau Instituut.

In this study we draw conclusions that are important for public and political discussion about the synthetic cell and for the development of the synthetic cell itself. The research approach provides insights into the issues that the visitors to Dutch Design Week mention with regard to the development of synthetic cell technology. In addition to the agenda that the *Future Panel on Synthetic Life* has produced, this study provides an initial agenda of issues that the interviewed

visitors to Dutch Design Week thought are important for further discussion. The views of experts are thus supplemented with those of citizens.

Reading guide
Chapter 1 describes the conceptual framework, or narrative method, with which we investigated how citizens socially assess technology, synthetic biology and synthetic cell technology.

In Chapter 2, we test whether the narratives from our conceptual framework on wishes, concerns and governance approaches can also be found in studies of public reactions to synthetic biology and new technological developments in general.

Chapter 3 discusses the perspectives of visitors to Dutch Design Week on the development of the synthetic cell. Which wishes, concerns and governance approaches do we see reflected in these perspectives?

Finally, Chapter 4 concludes with lessons for the further development of the synthetic cell and themes for a public dialogue on the synthetic cell.

1 Narratives about technology

To analyse citizens' societal assessment of synthetic cell technology, we use a narrative method. Citizens use narratives to give meaning to new technologies. These narratives include opportunities that people see and concerns that they have. There are also narratives about how the development of technology should be governed according to citizens – so-called governance narratives. This chapter first describes common narratives about expectations regarding the societal implications of technology. We then discuss various innovation governance narratives.

1.1 Making sense of technology

To gain a better understanding of how citizens think and talk about emerging technologies, we use the concept of *narrative*. In his three-part work *Time and narrative,* the French philosopher Paul Ricoeur (1913-2005) describes this concept as the way in which people experience time (Ricoeur, 1984; 1985a; 1985b). That is, how they interpret the past and understand future possibilities (see also Crowley, 2003). A narrative about a new technology is thus the translation that people make on the basis of stories about, or their own experiences with, (similar) technologies in the past into an expectation for a future society in which the new technology has been given a place. As such, they help people to process certain experiences, to communicate these to others and to form their own opinions with regard to the new technology (Gabriel, 2015). In other words, they offer people the opportunity to give meaning to technologies that are unknown to them (Macnaghten et al., 2015).

Narratives develop in the interactions between people and are deeply embedded in culture (Macnaghten et al., 2015). A narrative often does not need further explanation and appeals to our emotions (Heller, 2005). Heller (2005) also describes a narrative as an *archè* ('beginning' in ancient Greek) of a culture. According to Heller, people always return to these archetypal stories, which form the starting or end point of our imagination. In this way, narratives exercise power over our imagination and give legitimacy to new stories.

Every culture has its own archetypal narratives in the form of, for example, myths or religious views. In this report, we focus on the narratives about technology from European culture, that is, narratives that are shared by many people in countries on the European subcontinent. Research into these narratives provides insight into

how citizens' opinions about new technologies arise and which cultural and moral values underlie this.

1.1.1 Narratives on social implications of technology

Scientific breakthroughs contribute to social progress
In Europe, the majority of citizens believe in the value of science and technology for society. The starting point here is that progress in science and technology will have positive consequences for people's lives. This is the meta-narrative that scientific breakthroughs will contribute to social progress (Macnaghten et al., 2015). This meta-narrative originates from the Enlightenment and is the most dominant narrative in current public and political debate. Throughout history, people have always held out hope that science can improve their lives. This narrative is about trusting the value of science, striving for progress, fighting ignorance and instrumentalising nature for the betterment of humans (Macnaghten & Guivant, 2011).

In addition to this dominant narrative of progress, counter-narratives can also exist (Macnaghten et al., 2015). This means that, in addition to believing that a technology can contribute to societal progress, citizens can have concerns about possible negative consequences of that same technology. Building on research by Davies et al. (2009), Macnaghten et al. (2015) present five arche-narratives that citizens use to give meaning to their concerns about new technologies (see Table 1).

But there are other narratives within European culture besides the five narratives in Table 1. In this study, we focus on five counter-narratives that appear repeatedly and consistently in studies of citizens' views on different technologies (see, for example, Kearnes et al., 2006; Macnaghten, 2001, 2004; Macnaghten & Guivant, 2011; Macnaghten & Szerszynski, 2013).

The five counter-narratives are not independent of each other, but combine to form two meta-narratives that belong to two very different worlds: an ancient world and a modern world. Both of these meta-narratives show the doubts and concerns that people have about technology. That is why they are also called counter-narratives (Macnaghten et al., 2015).

Transgressing the natural order leads to evil
This ancient meta-narrative is about the transgression of the natural order by technology and focuses on the consequences when this technology enters society.

This meta-narrative includes the stories of desire (‘Be careful what you wish for’), evil (‘Pandora’s box’) and the sacred (‘Messing with nature’) (Dupuy, 2010).

The first narrative, ‘Be careful what you wish for’, is about the idea that getting exactly what you wish for can lead to unforeseen disasters and catastrophes. The narrative warns of the danger of limitless desire. The quest to realise this desire can lead to unforeseen consequences (Macnaghten et al., 2015).

The second narrative, ‘Pandora’s box’, is known from ancient Greek mythology and concerns a seductive closed box that, when opened, unleashes a whole range of human ills. This narrative is about the concern that radical scientific interventions may bring with them all sorts of unforeseen dangers and risks. For example, because people try to create things that are beyond our imagination (Macnaghten et al., 2015).

‘Messing with nature’ is the third and final narrative within the ancient meta-narrative and is about the potential of emerging technology to disrupt nature. This narrative is based on the idea that nature has sacred properties that ensure order in the human world. For example, nature sets moral and ethical boundaries that humans should not cross (Macnaghten et al., 2015).

Citizens are exploited and alienated by technology
This modern meta-narrative combines the stories of alienation (‘Kept in the dark’) and exploitation (‘The rich get richer and the poor get poorer’) (Dupuy, 2010). In this meta-narrative, it is not the results of science and technology that are scrutinised, but the exclusion of (certain groups of) citizens from the decision-making process surrounding the development and application of technology (Macnaghten et al., 2015).

The narrative ‘Kept in the dark’ translates the feeling of powerlessness in relation to an emerging technology. This story has two sides. On the one hand, it is about the control of governments or companies over the technology and the choice not to inform citizens about the new development. On the other hand, it is about the technology itself, which has certain properties that prevent society or politics from having any influence on its development (Macnaghten et al., 2015).

‘The rich get richer and the poor get poorer’ is the final narrative. This narrative is about the belief that emerging technology cannot avoid the logic of neoliberal political economy. As a result, only big corporations and those who are already powerful benefit from technology, while others are further disadvantaged (Macnaghten et al., 2015).

Table 1 Overview of narratives about the social implications of technology

Narrative	Short explanation
Dominant narrative: scientific breakthroughs contribute to societal progress	
1. Belief in progress	Advances in science and technology will improve people's lives.
Meta-counter narrative: Transgressing the natural order leads to evil	
2. Be careful what you wish for	Promises of new science and technology are often as seductive as they are dangerous.
3. Pandora's box	Even though technologies are not developed with malicious intent, they can lead to major, unforeseen changes and dangers.
4. Messing with nature	There is something sacred or pure about the foundation of nature that humans should not touch.
Meta-counter-narrative: Citizens are exploited and alienated by technology	
5. Kept in the dark	The development of new technologies evokes a sense of powerlessness and alienation.
6. The rich get richer and the poor get poorer	New technologies serve commercial interests and will contribute to inequality, both locally and globally.

Sources: Davies et al. (2009) and Macnaghten et al. (2015)

1.1.2 Narratives on societal steering of technology

How can you organise the development of technology in such a way that the technology and its application meet the wishes and needs of society? Technological innovation is influenced by various factors. Consider, for example, policy measures (e.g. science and industrial policy), the choices and convictions of individual researchers or designers of technology (e.g. the choice of a certain material or research approach), or the conditions of clients or funders of technological developments (e.g. the condition to involve citizens in the development process).

To interpret and classify visions of the steering of technology, we use the work of Van Est & Deuten (2024), who identify four governance approaches within the complex field of innovation policy in the Netherlands. We interpret these four approaches here as governance narratives as they have continuously played a role in the political and social debate on Dutch science and innovation policy since the 1970s.

Table 2 Overview of narratives on the governance of innovation

Governance narrative	Short explanation
1. Stimulating innovation for economic growth	Stimulating technological innovation to enhance the international competitiveness of domestic industries and thus boost economic growth.
2. Stimulating innovation for societal goals	Stimulating innovation that pursues policy objectives other than economic ones, for example in the field of energy policy, public water management, spatial planning or health policy. The needs of society are central to this.
3. Democratisation of innovation	Stimulating research into the social significance of science and technology, organising public participation and debate on the benefits and risks of new technologies, and nurturing that public input into, among other things, the political decision-making process.
4. Regulation and institutionalisation of innovation	Regulating and organising innovation so that it develops within socially desirable legal standards.

Based on Van Est & Deuten (2024)

The first two narratives both focus on stimulating innovation. The first narrative is about stimulating innovation for economic growth. The second narrative stimulates innovation to achieve other societal goals or policy goals, such as better healthcare or protecting the Netherlands against flooding.

The third narrative assumes that the democratisation of the development and use of technology is a central condition for the social embedding of innovation. This involves gaining insight into the social opportunities and risks of technology, informing citizens and politicians about this and stimulating the public and political debate about the social significance of science, technology and innovation.

Finally, the fourth approach is about regulating and organising technology through legislation and institutionalisation. Think of legislation in the area of food safety that new food products must comply with. Institutions are needed to guarantee this food safety. For example, the Netherlands Food and Consumer Product Safety Authority monitors the risks to food safety within companies.

The four innovation governance narratives discussed are not mutually exclusive. A person may therefore find several of these narratives important (Van Est & Deuten, 2024).

1.2 Narratives for meaningful technology

In the Chapter 2, we test the theory that citizens use narratives to give meaning to new technological developments. We do this by analysing findings from seven studies of citizens' perspectives on synthetic biology and technology in general, using the narratives introduced above about positive and negative expectations for technology and approaches to govern technology. If it turns out that the narratives introduced in this chapter on the consequences of technology and governing technology are reflected in the way citizens have been found to think about technology in general and about synthetic biology, this also empirically justifies our analysis of the conversations with citizens about the synthetic cell during Dutch Design Week in 2021 using the narrative method.

2 European citizens on synthetic biology and technology

Synthetic cell technology was an unfamiliar technology for visitors to Dutch Design Week 2021. Nevertheless, these visitors were able to engage in conversations about their expectations for this new technology and advise on how the development of synthetic cell technology could be steered. According to the narrative theory discussed in Chapter 1, citizens use stories about and experiences with (similar) technologies in the past to formulate expectations for a future society with the new technology.

To test this theory, this chapter analyses seven studies on citizens' perspectives of the development of new technology. We investigate to what extent the citizens in these studies, when discussing technology broadly or synthetic biology specifically, make use of the same narratives about the social implications of technology and the societal steering of technology presented in Chapter 1 (see Tables 1 and 2). These studies, which use both qualitative and quantitative methods, are less than ten years old. Four studies focus on public perspectives on synthetic biology, and three on perspectives on new technologies in general.

2.1 Public responses to synthetic biology

In recent years, several studies have been conducted on European citizens' reactions to synthetic biology and how they believe its development should proceed. Ancillotti et al. (2016) organised focus groups with citizens from Austria and the United Kingdom, among others. Betten et al. (2016) engaged with citizens in the Netherlands, and Starkbaum et al. (2015) in Austria and Germany. Jansma et al. (2021) discussed health technologies in the Netherlands, touching upon synthetic biology in the process.

Essentially, European citizens view synthetic biology positively. Medical applications and solutions to climate issues, in particular, are seen as valuable. Nevertheless, concerns also play a major role. These primarily involve the potential escape of newly created organisms. Participants fear that if these new organisms enter nature, they could multiply uncontrollably. The second most common concern is the creation of new life, our influence on nature through this, and the possibility of using this knowledge to create the perfect human being (Ancillotti et al., 2016; Betten et al., 2018).

The idea that technology will continue to develop regardless of citizens' opinions is mentioned as a third concern (Ancillotti et al., 2016; Betten et al., 2018). Some participants view technological developments as inevitable. Finally, citizens are concerned about how new technologies are controlled and who holds power over them (Jansma et al., 2021; Ancillotti et al., 2016; Betten et al., 2018). Additionally, there are concerns about the business model behind new developments in this field: who will profit and for whom will the technology be affordable (Ancillotti et al., 2016)?

To address these concerns, study participants believe research must occur under the right conditions. Firstly, there must be transparency and openness. The risks and uncertainties surrounding synthetic biology must be communicated to citizens from the start, there must be transparency about the financial sponsors of research, various interest groups must be involved throughout the technology's development, and synthetic biology products must receive a synthetic biology label (Ancillotti et al., 2016).

Secondly, participants believed there must be technical, legal, and political oversight of the new technology, and strict safety mechanisms must be employed (Starkbaum et al., 2015; Ancillotti et al., 2016; Betten et al., 2018). Thirdly, according to participants in the studies by Starkbaum et al. (2015) and Betten et al. (2018), there must be a balance between biosafety and space for innovation.

The main expectations and recommendations from the above studies and how these relate to the narratives from Chapter 1 are visually represented in Table 3 (Narratives on the social implications of technology) and Table 4 (Narratives on the societal steering of technology).

Table 3 Overlap between citizen conversations about synthetic biology and archetypal narratives about the social implications of technology

Narratives on the social implications of technology	**Issues from the literature regarding European citizens' expectations towards synthetic biology**				
	Opportunities for healthcare, agriculture and energy production	Escape of newly created organisms	Synthetic cell as unnatural	Uncontrolled developments	Power and accessibility
1. Belief in progress	XX				
2. Be careful what you wish for			XX		
3. Pandora's box		XX			
4. Messing with nature			XX		
5. Kept in the dark				XX	
6. The rich get richer and the poor get poorer					XX

Source: Rathenau Instituut

Table 4 Overlap between citizen conversations on synthetic biology and narratives on societal steering of technology

Narratives on societal steering of technology	Citizens' advice on steering synthetic biology		
	Ensure transparency and openness	Ensure safety and supervision	Find the balance between safe, responsible and progress
1. Stimulating innovation for economic growth			
2. Stimulating innovation for societal goals		XX	XX
3. Democratisation of innovation	XX	XX	
4. Regulation and institutionalisation of innovation		XX	

Source: Rathenau Instituut

2.2 Public responses to new technology

In recent years, several studies have been published regarding public views on emerging technologies and technological development in general. We analysed the findings of three studies: one European study and two studies from the United Kingdom.

The European Commission (EC) conducted a study in 2021 to better understand European citizens' opinions and perspectives on science and technology and how they believe new developments should be shaped. These Eurobarometer studies, which have taken place every two years since 1973, obtain their data through questionnaires and interviews with participants from European Union member states (27 in 2021).

In the United Kingdom, the Sciencewise Expert Resource Centre held seventeen citizen dialogues about emerging technologies, followed by approximately one thousand telephone interviews (Macnaghten & Chilvers, 2014). Additionally, a study was conducted in 2019 among nearly two thousand participants regarding their attitudes towards scientific developments in the United Kingdom (BEIS, 2020).

Implications: Concerns about Speed, Commerce, Ethics and Reliability

The three studies show that many European citizens view new technological developments positively. Compared to earlier studies, more people believe that science and technology make life easier, healthier and more comfortable (BEIS, 2020). However, citizens see four types of dangers.

Firstly, participants from all three studies are concerned about the speed at which technology is being developed. They find it difficult to properly control these developments and are wary of negative consequences for safety, human rights and equality.

Secondly, citizens are worried about the commercial aspects of new technology development. Many participants expect that new technologies will primarily be used by companies or wealthy people to generate more profit and that new technologies will provide more benefits to rich people than to poor people (EC, 2021; BEIS, 2020; Macnaghten & Chilvers, 2014).

Thirdly, participants support many of the discussed technologies – for example, artificial intelligence (AI) and genetic technologies – provided there are clear societal benefits and certain ethical boundaries are not crossed (BEIS, 2020; EC, 2021). Where those ethical boundaries lie differs for each technology. Nearly half of the participants from both the Eurobarometer study (2021) and the UK study (BEIS, 2020) indicate concerns that current regulations insufficiently specify which ethical and moral boundaries scientists must not cross in their research.

Fourthly and finally, citizens are concerned about the reliability of developers. Citizens fear that scientists do as they please, and they feel excluded from decision-making about technological development (BEIS, 2020; Macnaghten & Chilvers, 2014).

Governance: Expert Decisions, Control, Transparency, Boundaries
Participants in these studies believe that the government should promote interdisciplinarity and public participation in developing new technology (EC, 2021; BEIS, 2020; Macnaghten & Chilvers, 2014). Firstly, many citizens from the Eurobarometer study (2021) believe that decisions should ultimately be made by experts.

Secondly, according to citizens, governments must ensure that technology does not develop so rapidly that it becomes uncontrollable or that insufficient consideration is given to possible negative consequences. The speed of development must be reduced, at least until researchers are certain of the new technology's safety (EC, 2021; BEIS, 2020; Macnaghten & Chilvers, 2014).

Thirdly, citizens believe that technology developers should primarily make results public and be transparent about their work, business models and motivations (Macnaghten & Chilvers, 2014; EC, 2021).

Fourthly, we see division over the question of whether limits should be placed on what scientists may research and how strict the regulations should be (EC, 2021). The main expectations and recommendations from the above studies and how these relate to the narratives presented in Chapter 1 are visually represented in Table 5 (Narratives on social implications of technology) and Table 6 (Narratives on societal steering of technology).

Table 5 Overlap between citizen conversations about technology and archetypal narratives about the social implications of technology

Narratives on social implications of technology	**Issues from the literature regarding European citizens' expectations towards technology**				
	More opportunities than risks	Rapid developments	Commercial interests	Respect for ethical boundaries	Developer reliability
1. Belief in progress	XX				
2. Be careful what you wish for					
3. Pandora's box		XX			
4. Messing with nature				XX	
5. Kept in the dark		XX			XX
6. The rich get richer and the poor get poorer			XX		

Source: Rathenau Instituut

Table 6 Overlap between citizen conversations on technology and narratives on societal steering of technology

Narratives on societal steering of technology	**Citizens' advice on steering synthetic biology**			
	Organise interdisciplinarity and social participation	Make results public and be transparent	Stay in control of rapid developments	Regulate research and innovation
1. Stimulating innovation for economic growth				
2. Stimulating innovation for societal goals				
3. Democratisation of innovation	XX	XX	XX	
4. Regulation and institutionalisation of innovation			XX	XX

Source: Rathenau Instituut

2.3 Narratives on synthetic biology and technology

Tables 3, 4, 5 and 6 show that citizens' views on synthetic biology and technology in general strongly overlap with the archetypal narratives on the social implications of technology and on societal steering of technology from Chapter 1.

For both synthetic biology and technology in general, a large proportion of European citizens indicate that they recognise the positive aspects of new technologies. This means that the 'Belief in Progress' narrative is most dominant in the literature. Macnaghten et al. (2015) also noted this. Regarding concerns about the social implications of technology, we see the narratives 'Pandora's box' and 'Messing with nature' most frequently in the discussions. The narratives 'The rich get richer and the poor get poorer' and ‘Kept in the dark' appear next most often, followed by ‘Be careful what you wish for'.

The narratives of 'Pandora's box', 'Be careful what you wish for' and 'Messing with nature' emerge more strongly in discussions about synthetic cell technology than in those about technology in general. Conversely, we see the narrative 'The rich get

richer and the poor get poorer' more frequently when discussing technology in general. ‘Kept in the dark' appears equally often for both subjects.

Citizens' advice about societal steering of synthetic biology and technology also largely coincides. For both areas, citizens most often give advice that aligns with the governance narrative 'Democratisation of innovation’. This is followed by discussions primarily about ‘Regulation and institutionalisation of innovation'. This narrative appears more frequently in studies about technology than in those about synthetic biology. In discussions about synthetic biology, citizens advise on ‘Stimulating innovation for societal goals’. This advice hardly emerges in discussions about technology in general. ‘Stimulating innovation for economic growth' is barely mentioned by citizens for either area.

This means that with one exception, namely ‘Stimulating innovation for economic growth', all the narratives discussed in Chapter 1 have been discussed in the literature about citizens' responses to synthetic biology and technology in general. Moreover, all of the issues and advice raised by citizens could be categorised under one or more of those narratives, and no new narratives were formulated. This supports the idea that citizens make sense of new technologies through narratives which are deeply anchored in European culture. The comparison shows that citizens' concerns about technology in general are more focused on modern narratives, while concerns about synthetic biology focus more on traditional narratives.

This chapter thus demonstrates that almost all of the narratives about the social implications of technology and the societal steering of technology identified in Chapter 1 also appear in the seven studies regarding citizens' perceptions of synthetic biology or technology in general. Additionally, no new narratives were found. This chapter therefore provides an empirical test of the narrative theory and narrative method.

Consequently, we conclude that the narrative method is suitable for analysing the conversations held with Dutch Design Week visitors about synthetic cell technology, a largely unfamiliar technology for citizens. And that is what we do in the next chapter.

3 Citizens on synthetic cell technology

The findings in this chapter are based on an analysis of approximately one hundred conversations held in 2021 by researchers from the Rathenau Instituut with Dutch Design Week visitors about the synthetic cell. Visitors to this nine-day event came from various backgrounds and age groups: secondary school students, young adults and university students, adults and elderly people. In general, the visitors shared an interest in design and technology. The conversations offer an initial glimpse into citizens' responses to this technology. At present, there have been no other studies in Europe investigating public responses to the synthetic cell.

Dutch Design Week visitors primarily hope that the synthetic cell will contribute to medical solutions and solutions for climate issues. The visitors have various concerns. One concern is that a strong focus on risks will hinder social progress. Additionally, there are concerns about: the making of life and how far we may go in this regard, the uncontrollability of a technology that literally lives, and the question of who ultimately has power over the technology and its development.

We also asked Dutch Design Week visitors if they had advice for researchers and/or the government about how to properly guide the development of this technology. Although citizens have different desires and concerns regarding the synthetic cell, their advice about steering synthetic cell technology is consistent. Most visitors believe that scientists in particular bear the responsibility for responsible development of the technology. Scientists should do this through involving various disciplines, through interaction with citizens, and through maintaining a critical, careful and open attitude during the process with many moments for reflection. The visitors believe that the government primarily plays a role (at a distance) as a funder and facilitator of responsible research. The government can do this by encouraging interdisciplinary collaboration and by anticipating unintended consequences through legislation.

Tables 7 and 8 contain the visitors’ main expectations about the social implications of synthetic cell technology, their advice on the societal steering of synthetic cell technology, and how these relate to the narratives presented in Chapter 1.

3.1 Expectations for the synthetic cell

Table 7 Overlap between citizen conversations about synthetic cell technology and archetypal narratives about the social implications of technology

Narratives on social implications of technology	**Issues from the expectations of visitors to Dutch Design Week towards synthetic cell technology**				
	Opportunities for healthcare and climate	Technology for progress	Making life	(Un)controllability of living technology	Power over the synthetic cell
1. Belief in progress	XX	XX		XX	
2. Be careful what you wish for			XX		XX
3. Pandora's box				XX	
4. Messing with nature			XX		
5. Kept in the dark					XX
6. The rich get richer and the poor get poorer					XX

Source: Rathenau Instituut

Opportunities for healthcare and climate

Almost all interviewed Dutch Design Week visitors see opportunities for the synthetic cell in healthcare and climate. This aligns with the 'Belief in progress' narrative. Regarding medical solutions, people think of applications that can heal people, for example by growing new tissue or organs [24x], or treatments that prevent or cure diseases [15x]. The curing of cancer or Alzheimer's disease was mentioned several times.

'I think we live in a time where we must be open to innovation; the future cannot be predicted in advance, that's the beauty of it, we must approach it with enthusiasm and welcome developments.'

A small number of visitors go a step further and discuss the possibility of developing a new, improved human being [6x]. Regarding solutions for climate issues, the

interviewed visitors think of developing a new type of cultured meat [7x], cleaner materials [6x], organisms that clean up waste [6x], applications that support or restore nature by preventing extinction, for example [5x], cells that convert carbon dioxide (CO_2)to oxygen [4x], and cells that can break down nitrogen [2x].

Technology for progress

Another issue fits well within the 'Belief in progress' narrative, albeit in a different way. A small number of interviewed visitors are concerned about the possible negative influence of people's risk perception on innovation. According to them, a strong focus on risks could lead to society missing out on valuable technological innovations. The visitors indicate that they are happy with new developments. They state that humanity has always developed technologies and that new technologies help society to progress.

'I'm not particularly worried. The whole world continues to develop.'

They wish for sufficient space to be given to the development of the synthetic cell so that this technology can also help society move forward. They think that mistakes or unintended consequences are part of research and simply come with the job. The visitors believe that current laws and rules guide technological developments appropriately and say that you should primarily trust in the good in humans. Their biggest concern is that there is too much fear of new developments and that society might miss out on promising technologies as a result. Developments should be embraced, despite the risks. This issue is closely connected to the 'Belief in progress' narrative.

Making life

Fitting within the 'Messing with nature' narrative, a large majority of interviewed Dutch Design Week visitors are concerned about issues around the making of life. They fear that we as humans will 'play God' and their biggest concern is that researchers will create a 'perfect' human.

'Should we really get more autonomy over what happens on this globe? Maybe we'll play God too much?'

They emphasise that life cannot be engineered, and that it is beautiful precisely because people are different.

According to the visitors, people must also respect nature and we shouldn't tinker with it [4x]. The visitors pose important questions that we as a society must answer: what may we as humans do in relation to modifying nature? Shouldn't we leave nature as it is? Some participants indicate that humanity needs to treat nature

better and that the synthetic cell could negatively change our view of nature. According to these visitors, perfection is something that doesn't belong in nature. This is also precisely the point where most visitors draw the ethical line in what is or is not desirable for the synthetic cell.

Aligning with the narrative 'Be careful what you wish for', various interviewees warn that people shouldn't strive for perfection [10x] and the creation of new humans/beings [8x] in the context of medical solutions. Some participants also warn that you can't keep developing just for the sake of development. There must be a limit somewhere. The big question is where that ethical boundary lies. The visitors indicate that it is up to researchers to continue reflecting on their work and that researchers must not lose sight of societal interests.

'Nothing is as dangerous as forgetting in your laboratory that there's still a world around it.'

(Un)controllability of living technology

Some interviewees are concerned about losing control over how the synthetic cell will develop, especially when the cell starts to lead its own 'life'. The visitors wonder what happens 'if it starts multiplying?'. They fear that humanity will easily lose control over the cell and that the cell will 'proliferate' when released into nature. This could have a negative effect on nature.

According to some visitors, we can never fully predict what the consequences of the new technology will be. Are we unconsciously creating new problems? These thoughts are closely related to the arche-narrative 'Pandora's box'. At the same time, citizens also see opportunities in the possibility of controlling organisms' properties as with the synthetic cell. For example, organisms could be developed that actually help nature, such as creating algae that can convert CO_2 even better, or making cells that can clean up nature, or produce new raw materials. The perspectives of uncontrollability and controllability are often raised simultaneously in a conversation. The notion of controllability aligns well with the 'Belief in progress' narrative, because control over nature helps us shape it to our will and use it for our own goals and desires.

According to a large proportion of the interviewed visitors, the choice to develop the synthetic cell or not depends on what it will ultimately be used for. Some of them wish not to always choose technology as a solution to problems, but to first look for alternatives as well. In this context, visitors believe it is important to think carefully about the technology and what the possible implications could be before the

technology exists. These visitors are primarily concerned about the uncontrollability [12x] and the unknown elements [6x] of a new life such as the synthetic cell.

Power over the synthetic cell
Finally, a number of Dutch Design Week visitors are concerned about the uncontrollability of the process within which new technology is developed. The visitors wonder if there is sufficient oversight of the development and application of the synthetic cell and who has power over this. What if the technology falls into the wrong hands?

The biggest concern is that society has no control over the technology [10x]. This is a different concern from the 'uncontrollability of living technology'. The fear here lies in the idea that without adequate regulation, the cell may be used for anything and there is no control over the applications. Visitors refer to experiences with other technologies, such as social media.

'Everything can be used against humans, all new technologies, the smartphone for example, super handy for humanity, but it can also be used for war. So I think this is very useful for medicine, but it could also be used as a bio-virus [...] if it falls into the wrong hands.'

Various interviewed visitors – who alternately think more positively or negatively about the usefulness and applications of the synthetic cell – believe that technology will continue to develop and that you cannot stop this. This touches on the 'Kept in the dark' narrative. Visitors fear that there is no openness and transparency surrounding the development of the synthetic cell. They refer to technologies such as facial recognition, genetically modified organisms, social media, smartphones, and the internet. With these technologies, visitors feel that citizens had little to no influence on their development.

'[Social media apps] are created and then they go their own way. We no longer have control over which direction those algorithms go. That could be the same with such a cell. You might be at the cradle of the new technology. But what happens with it afterwards you can very quickly lose control over.'

The visitors not only wonder who will have influence over the technology but also who will benefit from it. They fear that the synthetic cell will only improve the lives of a few wealthier people. This aligns with the narrative 'The rich get richer and the poor get poorer'. The concerns especially arise when visitors imagine that people who have money or can make money from this get control of the technology.

Visitors were also concerned about the emergence of unintended applications based on the knowledge gained during the development of the synthetic cell. A technology that was developed with all good intentions and promises and that does exactly what it was developed for can still ultimately turn out negatively for society: a concern that fits within the narrative 'Be careful what you wish for'. Visitors regularly refer to the promises surrounding the development of the internet and social media and the negative effects these technologies now have on our society.

3.2 Societal steering of synthetic cell technology

Ensure public involvement
The interviewed visitors to Dutch Design Week most often mentioned the importance of public involvement in the development of the synthetic cell [15x]. Society must be aware of the developments, understand what is at stake and be able to think or talk about this. Science in particular should be more open, actively share knowledge and enter into discussions with a diverse group of people. In addition to science, the government was also mentioned as a facilitator of social dialogue. In this we recognise the governance narrative 'Democratisation of innovation'.

Table 8 Overlap between citizen advice on synthetic cell technology and the archetypal narratives on societal steering of technology

Narratives on societal steering of technology	**Citizen advice on steering synthetic cell technology**			
	Ensure public involvement	Ensure critical reflection	Anticipate unintended consequences	Facilitate and stimulate innovation
1. Stimulating innovation for economic growth				
2. Stimulating innovation for societal goals			XX	XX
3.Democratisation of innovation	XX	XX	XX	
4. Regulation and institutionalisation of innovation			XX	

Source: Rathenau Instituut

Ensure critical reflection

Secondly, according to visitors, it is important that within the development of the synthetic cell there is thoroughness, an open attitude, awareness and critical reflection [11x]. This fits within the governance narrative 'Democratisation of innovation'. Researchers must be aware of their influence on the technology, think critically at every step of the process, continuously question why they are building the cell, and not forget that there is an entire world outside the lab. Moreover, it is important that multiple disciplines are involved in the research [6x]. Think of examining this technology at legal and ethical levels or involving disciplines such as psychology and sociology. It is important that involving different disciplines is not a one-time activity, but that the development of the synthetic cell is an iterative process where new knowledge is used to repeatedly pause and consider the development and how it can best be organised. The involved experts and laypeople should not only be advocates of the technology; critical people are particularly valuable.

Government must anticipate unintended consequences and provide oversight

According to many Dutch Design Week visitors, the government has a role to play in anticipating new developments by carefully considering all possible positive and

negative consequences that the synthetic cell could have on society and by developing new legislation, for example [7x]. Here too, involving different disciplines is important. This advice aligns with the governance narratives 'Democratisation of innovation' and 'Regulation and institutionalisation of innovation'. Because the synthetic cell concerns new life built by humans, it is particularly important that a clear ethical boundary is set and monitored. What is permitted and what isn't? Additionally, some visitors indicate that the government must prevent the technology from falling into the wrong hands, for example 'people with malicious intentions' [6x]. Others indicate that the new technology should be accessible to everyone [4x]. This would further stimulate development. It is important that there is transparency about the technology's business model and who will have power over the technology. Visitors regularly referred to other technologies, such as smartphones and the internet, where visitors felt this transparency and power distribution was not properly arranged.

Government must facilitate and stimulate innovation
A dilemma that many participants [18x] raise is that new technological developments have both positive and negative aspects, making it difficult to make a judgement about the development. This gives visitors a 'mixed feeling' about the synthetic cell.

'It can be a utopia or a dystopia, it can go either way, so it's actually quite a confusing situation. On one hand, scientifically speaking, an enormous challenge, [it] can lead to new health improvements, on the other hand, you don't know if it will be misused, a bit of a mixed feeling.'

Despite this dilemma, many visitors believe that the government should facilitate and stimulate innovation. It is important that the government is open to new developments and invests in innovation so that society can benefit from it. The governance narrative 'Stimulating innovation for societal goals' clearly emerges here.

The governance narrative 'Stimulating innovation for economic growth' is mentioned occasionally in our conversations. However, it is emphasised by the visitors that innovation is important for solving society's problems, not for making profit.

3.3 Narratives about the synthetic cell

Regarding synthetic cell technology, the interviewed Dutch Design Week visitors indicate that they recognise the positive aspects of the new technology. This means that the narrative 'Belief in progress' is most dominant. There is a strong idea that

technologies like the synthetic cell should not be rejected, but that attention should be paid to ensuring the technology is developed 'in the right way'.

Citizens support synthetic cell technology particularly when it is used for medical applications and climate goals. In conversations related to the narrative 'Belief in progress', concern is also expressed that when too much emphasis is placed on risks – in other words, when the counter-narratives receive too much attention – opportunities for technological and social progress might be missed.

Regarding concerns about the social implications of synthetic cell technology, we see the narrative 'Messing with nature' most frequently. Visitors question how far humans should be allowed to intervene in nature. The visitors indicate that people should have more respect for nature and therefore should be cautious about tampering with it. They also question whether we as a society can control living technologies.

The second most common narrative is 'Be careful what you wish for'. Dutch Design Week visitors indicate that they don't trust the developers' promises. They fear the consequences of the new technology for humans, society and the planet.
In relation to the synthetic cell, citizens warn that researchers should not strive for perfection in the context of medical solutions and that society cannot endlessly continue developing just because it can. We must draw a line somewhere, because even well-intentioned developments can have negative consequences. Dutch Design Week visitors often refer to previous technologies with great promise that ultimately – in their view – turned out to be less good or even bad. These negative consequences can come from a lack of transparency and openness from developers. There is also fear that the technology is primarily being developed to make money, rather than to help people and society.

Third is the narrative 'Pandora's box'. Dutch Design Week visitors fear that as a society we can never fully predict the consequences of synthetic cell technology. The interviewees also mention that it is inevitable that people will make mistakes. Such concerns are specifically expressed when it comes to deliberate release by malicious persons or the accidental escape of synthetic organisms into nature. This stems from fear of the uncontrollable nature of living technologies, and fear of the unknown influence of newly created organisms on nature.

The narratives 'The rich get richer and the poor get poorer' and 'Be careful what you wish for' appear most frequently after 'Pandora's box', followed by 'Kept in the dark'. Dutch Design Week visitors wonder who has influence over synthetic cell technology and who will benefit from it. These concerns especially arise when visitors imagine that people who have money or can make money from it have

power over the technology. In line with the narrative 'Kept in the dark', visitors occasionally indicate that it feels as if they are being swept along in a development where they have little influence, but which raises many questions and uncertainties for them.

The visitors give most advice for the societal steering of technology that aligns with the governance narrative 'Democratisation of innovation’. Next there is primarily discussion about 'Regulation and institutionalisation of innovation' and to a lesser extent about 'Stimulating innovation for societal goals'. 'Stimulating innovation for economic growth’ is barely mentioned by visitors.

'Democratisation of innovation' is the governance narrative that plays the strongest role in conversations with citizens about synthetic cell technology. The surveyed Dutch Design Week visitors believe that the synthetic cell must be developed responsibly. This means that research must be accessible, that synthetic cell developers must engage with citizens to stimulate awareness, and that they must involve different disciplines in the development process. Additionally, it is important that researchers have an open attitude when engaging with experts from other fields or with other stakeholders, that they critically examine their own work, and that they are aware of the possible implications of the research.

Second most prominent is the governance narrative 'Regulation and institutionalisation of innovation’. Visitors indicate that misuse of the synthetic cell by individuals or organisations must be prevented and that there must be a clear ethical boundary that developers must adhere to. The government must ensure that developers stick to this boundary but, according to visitors, the government should not determine where this boundary lies themselves. This is up to citizens and experts from various disciplines, such as ethicists. Researchers must first be certain of the synthetic cell's safety before the government may decide whether or not to introduce the technology into society.

The narrative 'Stimulating innovation for societal goals' appears third most frequently in conversations about the synthetic cell. Visitors see the benefits of the synthetic cell and think it is important that the government is open to new developments and invests in innovation so that society can benefit from it.

4 Conclusion

In this report, we examined how citizens view developments in the field of synthetic cells. To this end, we conducted conversations with visitors to Dutch Design Week in 2021. We asked them about the potential social implications of this new technological development and how scientists and the government should guide and direct this development.

We analysed the outcomes of these conversations, and subsequently interpreted them using the narrative method. For this task, Chapter 1 distinguished six archetypal narratives about the social implications of technology (see Table 1 in Section 1.1.1) and four narratives on societal steering of technology (governance narratives) (see Table 2 in Section 1.1.2). We tested these narratives against studies of citizen perspectives on synthetic biology and technology in general.

The narratives applied in this report do not cover all societal expectations and ways of steering innovation regarding the synthetic cell. Moreover, new narratives may form in the future. However, previous research and the analysed studies of European citizens' perspectives on the development of synthetic biology and new technologies show that our chosen narratives consistently remain central.

The analysis in this report shows that, with one exception, all narratives were raised in the interaction with Dutch Design Week visitors regarding synthetic cell technology and in studies of European citizens' views on synthetic biology and technology in general. All issues and advice from citizens could be classified under one or more narratives, and no new narratives were formulated.

Below, we reflect on the significance of our research. Firstly, we reflect on the societal and political debate surrounding synthetic cell technology. Secondly, we examine how the governance of technological development should take shape.

4.1 Important values for the synthetic cell

The development of synthetic cell technology is new and receives little attention in public debate. The conversations at Dutch Design Week were a first step towards such societal dialogue. From a democratic perspective, it is important that the development of synthetic cell technology goes hand-in-hand with public and political debate (see also Section 4.2).

Our study shows the wishes and concerns of the interviewed visitors to Dutch Design Week 2021 regarding synthetic cell technology.

The analysis of these conversations shows that the issues citizens raise about synthetic cell technology are rooted in six archetypal narratives about technology in European culture.

It is therefore important to conduct and shape the societal and political debate about synthetic cell technology more broadly from these narratives and the cultural, moral and public values underlying them. We identify eight values within the expectations of Dutch Design Week visitors: sustainability, health, innovation, ethical limits, control (of the technology), control (of the technological development process), transparency and inclusiveness, and equality. We examine these eight values below.

Technological progress and societal goals
In line with the 'Belief in progress' narrative, our analysis shows that many Dutch Design Week visitors believe that technological innovation helps society advance. However, they believe that innovation should focus on solutions for societal challenges. They place great value on the question of why (with which applications in mind) a technology is being developed. Visitors were particularly positive about the development of synthetic cell technology that contributes to solutions for climate and health. It is therefore valuable to maintain good insight into citizens' expectations regarding the synthetic cell.

Important values within citizens' expectations are:

1. Sustainability: how do we ensure that the development of synthetic cell technology contributes to a more sustainable society?
2. Health: how do we ensure that the development of synthetic cell technology contributes to a healthier society?
3. Innovation: how do we weigh opportunities against risks? How do we prevent our focus on the risks of the synthetic cell from hindering innovation too much?

Ethical issues and naturalness
Our study shows that Dutch Design Week visitors' concerns regarding the consequences of synthetic cell technology are connected to deeply rooted centuries-old narratives about desire ('Be careful what you wish for'), evil ('Pandora's box') and the sacred ('Messing with nature'). These narratives are about

transgressing the natural order and thus strongly align with the nature of synthetic cell technology as living technology (see also Bedau et al., 2010).

Dutch Design Week visitors question how far humans may go in modifying nature, to what extent it is possible to control a living technology once it enters nature, and whether the promises of technology developers can be trusted. Because even well-intentioned developments can have negative consequences for humans, society and nature.

Important values within citizens' expectations are:

4. Ethical limits: what may humans do in relation to (modifying) nature? Should humanity not leave nature as it is? How do we prevent the pursuit of perfection from becoming the goal of innovation?
5. Control (of the technology): how do we as a society maintain control over a living technology like the synthetic cell? Do we want to release something artificial or synthetic like the synthetic cell into nature? How do we prevent the synthetic cell from proliferating uncontrollably?

Power and Equality

To a lesser extent than the traditional narratives, more modern narratives about alienation ('Kept in the dark') and exploitation ('The rich get richer and the poor get poorer') also appear in citizens' perspectives on synthetic cell technology. These narratives concern the decision-making process surrounding the development and application of technology. Dutch Design Week visitors primarily express concerns about the distribution of power within the technology's development and about the distribution of costs and benefits of the eventual applications that arise from it.

Important values within citizens' expectations are:

6. Control (of the technological development process): how do we as a society oversee the development and application of synthetic cell technology? How do we prevent the technology from falling into the wrong hands?
7. Transparency and inclusiveness: who has access to the development of synthetic cell technology? Who gets to participate in decision-making about it?
8. Equality: who bears the costs and who receives the benefits of synthetic cell technology? Who can and may ultimately use the applications of the synthetic cell?

4.2 Governance of synthetic cell technology

Our study shows that interviewed Dutch Design Week visitors have diverse expectations and varying levels of concern about the social implications of synthetic cell technology. Nevertheless, visitors are consistent about how the governance of this technology should be organised. Visitors' advice about governance aligns well with three of the four narratives on societal steering of technology discussed in Chapter 1.

The governance narrative ‘Stimulating innovation for economic growth’ is not mentioned by the interviewed Dutch Design Week visitors, although this has historically been the dominant governance approach within Dutch innovation policy (van Est & Deuten, 2024). Visitors' thinking about steering innovation aligns well with three governance narratives: 'Stimulating innovation for societal goals’, 'Democratisation of innovation’ and 'Regulation and institutionalisation of innovation'. We therefore discuss these three governance approaches below.

Innovation for societal goals
As described above, Dutch Design Week visitors would like to see innovation contribute to societal challenges and public goals. For the synthetic cell, the interviewed visitors see value in solutions for good healthcare and sustainability. This wish aligns with one of the four recommendations from the *Future Panel on Synthetic Life*: 'Ensure that the synthetic cell contributes to a fair and sustainable future' (Aarts et al., 2022, p. 65).

The Dutch Design Week visitors' desire to use technological innovation for societal goals aligns with the recent emergence of mission-driven and challenge-oriented innovation policy (Mazzucato, 2021; Rathenau Instituut, 2021). This is also termed the 'normative turn' in innovation policy (Daimer et al., 2012), as innovation is seen as a policy instrument to guide socio-technical changes in a particular political direction.

This raises the question of how scientific research – and particularly research into the synthetic cell – can be structured so that the results indeed contribute to societal goals. It is clear that this requires an interdisciplinary approach. The principles of responsible research and innovation can serve as guidance here (European Commission, 2013; Stilgoe et al., 2013; Owen et al., 2013).

Democratisation
Dutch Design Week visitors believe that democratisation of research and innovation is needed to ensure that research into synthetic cells contributes to solutions for climate and health. There must be research into the societal significance of science

and technology, citizens must have a place within research, there must be diversity and transparency, and public debate must be organised.

The visitors formulate different roles for developers and government within the democratisation of synthetic cell technology development: Technology developers have the responsibility to give sufficient consideration to the safety and societal aspects of the technology, to involve a diverse group of experts, stakeholders and/or citizens in a timely manner, and to make knowledge about the technology public and accessible.

Safety is an important issue for Dutch Design Week visitors. They believe that a balance must be found between guaranteeing safety on one hand and embracing innovation on the other. While a legal framework exists in the Netherlands for biosafety (Rathenau Instituut, 2022), according to the *Future Panel on Synthetic Life*, the synthetic cell may raise new questions (Aarts et al., 2022). The synthetic cell may look very different from the natural cell, making it difficult to anticipate what risks might arise. Therefore, the risks associated with conventional biotechnology may only partially apply, and more research is needed into the risks of the synthetic cell.

The development of research into synthetic cells raises more ethical issues than just safety. The interviewed Dutch Design Week visitors therefore envision a role for the government as a facilitator of societal innovation. Respondents believe that the government should anticipate new developments by organising societal dialogues. The government should also investigate and establish ethical boundaries in consultation with various experts and stakeholders. In consultation with researchers, experts and citizens, the government must determine the right direction for technology development and where the boundary lies in what may be researched and developed. Section 4.1 outlines an agenda for this political and societal debate based on the values that citizens consider important.

Regulation and institutionalisation

When more knowledge becomes available about the safety risks and ethical questions surrounding the synthetic cell, new legislation and regulations can be developed. Dutch Design Week visitors therefore also envision a role for the government as a supervisor of societal innovation that anticipates new developments with legislation and regulations. As a supervisor, the government must ensure that safety is guaranteed, ethical boundaries are not crossed, prevent technology from falling into the wrong hands, and ensure that access to the technology is equally distributed across society.

4.3 Synthetic cell technology for society

The insights in this report show how citizens' expectations for a new technology are interwoven with their vision for the development of this technology. The visitors to Dutch Design Week are neither for nor against synthetic cell technology, but rather see advantages and disadvantages simultaneously. They believe that how and for what purpose a technology is developed determines what impact it will have on society.

The visitors believe that to develop synthetic cell technology in a way that aligns with society's wishes, innovation should firstly be directed towards solutions for societal issues. This seems like good news, as in recent years the Dutch Cabinet has initiated an important change by focusing innovation policy more on major societal challenges (the mission-driven top sectors and innovation policy from 2019). However, Dutch innovation policy still primarily views societal challenges as economic opportunities for businesses and as potential application areas for new key technologies. Therefore, challenges that cannot fulfil either of these functions remain out of reach.

The current innovation policy thus appears to contradict Dutch Design Week visitors' views on technology development. Moreover, none of the insights from our research show that Dutch Design Week visitors value innovation aimed at stimulating the economy. Furthermore, various concerns of the interviewed visitors about the synthetic cell are directly linked to the economic motivation of technology developers. For example, the concern that new technologies only provide value for a small group of people.

Secondly, synthetic cell technology for society requires democratisation of the innovation process. The government's view of societal challenges as economic opportunities has led to policy instruments still being too focused on promoting innovative entrepreneurship and public-private partnerships. More attention is needed to new ways of innovating where the societal embedding of innovations is central. Particularly in the case of innovations in healthcare, energy and agriculture, it is important to maintain a broad perspective on implementation (Rathenau Instituut, 2019).

This requires, among other things, encouragement of and space for involving a broader group of stakeholders and societal debate. The underlying problems of each societal challenge are different and require a process tailored to this. According to Dutch Design Week visitors, it is up to the government to stimulate and enable this democratisation of research and innovation. This calls for a

government that, like technology developers, dares to experiment, takes risks and is adaptable (Rathenau Instituut, 2020).

Finally, the development of the synthetic cell requires regulation and institutionalisation. But before the synthetic cell can be developed, there must be understanding of the societal aspects of the technology. A democratic way of innovating can be used for this. Additionally, according to Dutch Design Week visitors, the government must work with experts and society to investigate in a timely manner where social and ethical boundaries should lie for research into the synthetic cell. The conversations at Dutch Design Week are already a first step towards this. The values that emerge from these conversations (Section 4.1) provide a basis for the continuation of the societal and political debate about the synthetic cell.

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Appendix: Research Method

Dutch Design Week 2021

In the autumn of 2021, the Rathenau Instituut held conversations with visitors to Dutch Design Week about the societal significance of the synthetic cell. The Dutch Design Week is an international event that focuses on various facets of design, including topics surrounding the relationship between technology and humans. For various reasons, we saw the Dutch Design Week as a suitable place to start the public dialogue about life with the synthetic cell. The event offers the opportunity to speak to a large and diverse group of people in a short period of time. In addition, one of the subthemes of Dutch Design Week that year was 'It's in our nature', which focused on the relationship between humans and nature. The development of the synthetic cell fitted in well with that theme. Visitors to this nine-day event come from different backgrounds and age groups: high school students, young adults and students, adults and the elderly. In general, the visitors shared an interest in design and technology.

In order to inform visitors to Dutch Design Week about developments in the field of the synthetic cell and to discuss this with each other and with us, designer Mies Loogman built an art installation. The art installation served as a conversation starter and stimulated visitors to talk to each other about life with or without the synthetic cell. The installation consisted of a cradle with a mobile above it with questions, and was intended to represent the future nursery of the synthetic cell. In the background, the podcast series about the synthetic cell called Herschept played, which was developed by the Rathenau Instituut and Mies Loogman prior to Dutch Design Week. In the podcast series Herschept, Mies Loogman, together with the Rathenau Instituut, investigates how humans 'recreate' life by creating a synthetic cell.

Visitors to the installation were welcomed by the hosts (researchers from the Rathenau Instituut, Mies Loogman, members of the Future Panel[3] and researchers from the BaSyC consortium) to the baby shower of the future synthetic cell. The conversations with visitors that followed focused on their wishes and concerns for the future synthetic cell and their advice for the makers of the technology (the researchers) and government. In order to structure the conversations with the

3 Within the BaSyC consortium, the Rathenau Instituut, in collaboration with Radboud University in Nijmegen, organized a *Future Panel for Synthetic Life*. This panel explored the societal challenges and dilemmas surrounding synthetic life and possible implications of this research with the aim of setting a first preliminary agenda for the political, social and scientific debate on the synthetic cell. The most important discussion points, insights, challenges and dilemmas that the panel identified have been published in a position paper (Aarts et al., 2022).

visitors, a conversation card was developed based on the research. All hosts were trained in the use this conversation card in preparation for the event.

At the art installation, small gifts were given (test tubes containing candied anise seeds with pink, blue or white sugar coating – a delicacy eaten in the Netherlands to celebrate the birth of a child) with a QR code link to the podcast series. Visitors also received a postcard with the QR code and a number of questions to support the visitor to think about their wishes for the synthetic cell and start the conversation. The questions on the postcard were the same as the questions on the mobile and were in line with the conversation guide.

Over the nine days of Dutch Design Week 2021, approximately one thousand conversations were held, of which about a hundred were recorded and analysed for this research. Most conversations were held in Dutch and a few in English. The conversations took place in various group sizes, from two people (host and visitor) to five people.

Analysis
The conversations were recorded with written permission from the participants. Extensive notes were taken of the recordings, and the transcripts were manually coded in Word. The analysis was ultimately an iterative process, in which themes were first developed using the grounded theory method. The themes from the analysis were translated into issues within the expectations of visitors about the synthetic cell and advice for the technology developers. We then looked at the extent to which these issues and advice did or did not match the narratives from the literature (see Chapter 1). The four-eyes principle was used in the analysis. Two researchers performed the above analysis independently in order to reduce bias.

Literature review
In addition to the data analysis, a literature study was conducted to gain insight into existing knowledge regarding citizens' perspectives on the development of synthetic biology and technology in general. And to test the narrative method from Chapter 1 based on these insights. The studies were selected based on a number of characteristics. First, the studies had to address both the expectations of European citizens about the consequences of synthetic biology and technology and the views of citizens on how the development of these technologies should be organised.

Second, preference was given to papers that were no older than ten years (published after 2014). The third criterion was the size of the study. In the case of a larger supply, studies that investigated a larger group of European citizens were selected. A total of seven studies were analysed: Three studies on technology in general and four studies on synthetic biology.

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