"Some Kind of Genetic Engineering… Only One Step Further"—Public Perceptions of Synthetic Biology in Austria

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1 Introduction

> I have an idea for how we could define synthetic biology. Namely, if we could define it, if we could accept the definition that it is some kind of genetic engineering… only one step further, a considerable step further.[1]

This proposition was made by a participant in a citizen panel (CP) conducted in November 2012 in Vienna, Austria. The quote points to a central issue related to synthetic biology and its public perception: the embedding of the research field within the discursive frame of genetic engineering. The drawing of parallels between synthetic biology and genetic engineering has for several years been discussed in the scientific literature (Kronberger et al. 2009, 2012; Pauwels 2009; Torgersen and Hampel 2012; Torgersen and Schmidt 2013). Some stakeholders and policy makers deem the parallel problematic because they fear a repetition of the controversy over genetically modified crops at the end of the 1990s[2] (Kaiser 2012; Kronberger 2012; Tait 2009, 2012; Torgersen 2009; Torgersen and Hampel 2012). This concern can be reinforced by empirical studies showing a persistent low public support for genetically modified crops in Europe (Gaskell et al. 2010) and suspicion towards genetic engineering in general (Rehbinder et al. 2009, p. 152). On the other hand, an understanding of synthetic biology as being a continuation of classic

[1]Female participant in CP 1, adults aged 50+, Vienna. Citizen panels were conducted in German and transcripts quoted in this chapter have been translated to English by the author.

[2]The anti-GMO movement in Europe at the end of the 1990s was triggered by two events: (1) the import of GM crops—not labeled as such—from the U.S. to Europe, (2) the outbreak of the BSE scandal. Within this context, Austria was one of the first countries where anti-GMO movements emerged (Seifert 2002, 2003).

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genetic engineering could downplay the risks, unknowns and depth of interventions of synthetic biology, which may exceed those of traditional biotechnology (Engelhard 2010, 2011).

For synthetic biology the issue of framing is challenging because concrete applications are rare, expected benefits rely on promissory visions of the future, and long-term impacts are unpredictable. Furthermore, even between experts consensus about the exact definition of synthetic biology seems difficult to find (Calvert and Martin 2009; Kitney and Freemont 2012; SCENIHR et al. 2014). In one commonly quoted definition, synthetic biology is referred to as "(A) the design and construction of new biological parts, devices, and systems and (B) the re-design of existing, natural biological systems for useful purposes".[3] Synthetic biology is described as an interdisciplinary research field involving knowledge and practices of biology, chemistry, physics, engineering, and computer science (Nature Biotechnology 2009) with possible applications ranging from the production of drugs and vaccines (Ruder et al. 2011), via biosensors for the detection of toxins, to the production of biofuels and biodegradable plastics (Kitney and Freemont 2012; Schmidt 2012). One of its pioneers, Drew Endy, named it the "engineering of biology" (Endy 2005). Critical voices, such as the NGOs Friends of the Earth and ETC Group, even name it "extreme genetic engineering" (ETC Group 2007; Friends of the Earth et al. 2012). These manifold conceptualizations leave room for the question whether synthetic biology is something new (Andrianantoandro et al. 2006; Ball 2004; Benner and Sismour 2005; Endy 2005), or a progression of traditional genetic engineering (De Lorenzo and Danchin 2008; De Vriend 2006). Consequently, it will be interesting to see how synthetic biology will be perceived, framed, and discussed outside of expert circles.

Throughout the last decades, and since the advent of the anti-GMO movement in particular, the introduction of new technologies has been accompanied by governance strategies that foster dialogue with stakeholders and the public (Marris and Rose 2010; Tait 2009). Synthetic biology is no exception to this. Every year national and international expert panels, ethics boards, and governmental advisory commissions publish reports and recommendations which underline the importance of public dialogue in emerging research fields like synthetic biology (e.g. European Group on Ethics 2009; Nuffield Council on Bioethics 2012; OECD Royal Society 2010; Presidential Commission for the Study of Bioethical Issues 2010). On the other hand, parts of the scientific community fear that public engagement could trigger technophobic discourses that hamper innovation (Graur 2007; Stirling 2012). Others question the ability of "ordinary" and "non-scientifically trained" (McHughen 2007) citizens to voice informed opinions on complex technological issues. Still others argue that public engagement is used as strategy to prevent conflict, restore trust in authorities, and would serve the primary goal of science promotion (Torgersen 2009; Stirling 2012; Wynne 2006). Indeed, within science and technology studies discussions about aims, impacts, power relations, and inclusiveness of engagement

[3] www.syntheticbiology.org. Accessed 25 Mar 2015.

experiments have a long tradition (Bogner 2012; Delgado et al. 2011; Irwin et al. 2013; Marris and Rose 2010; Stirling 2008; Tait 2009; Wickson et al. 2010; Wynne 2006; see also Seitz, this volume), and social scientists are critically reflecting their own roles within engagement experiments, (ELSI) research programs, or framing in general (Calvert and Martin 2009; Marris and Rose 2010; Mohr and Raman 2012; Stilgoe et al. 2014; Stirling 2008, 2012; Torgersen 2009).

So far, public engagement projects with the aim of involving citizens and/or stakeholders on questions of governance and incorporating their recommendations into policy making have been rare in the field of synthetic biology (e.g. BBSRC and EPSRC 2010; Royal Academy of Engineering 2009; but cf. Rerimassie, this volume). In the literature we rather find empirical studies focusing on public perceptions per se. Large-scale surveys have been carried out on both sides of the Atlantic (Gaskell et al. 2010; Hart Research Associates 2008, 2009, 2010, 2013; Kahan et al. 2009), and a considerable number of studies have used a combination of qualitative and quantitative methods to investigate the public perception of synthetic biology in a variety of countries (Dragojlovic and Einsiedel 2012; Hart Research Associates 2008, 2009; Kronberger et al. 2009, 2012; Navid and Einsiedel 2012; Pauwels 2009, 2013; Schmidt et al. 2008). The results of these studies show that recurring issues that matter to respondents are: long-term impacts, side effects, economic interests, intellectual property rights, distributional justice, notions of "life" and morality of constructing "artificial life", safety, security and regulation of synthetic biology.

Furthermore, qualitative studies focused on the framing of synthetic biology by experts, stakeholders or the media and the influence of certain framings on public perceptions (Ancillotti and Eriksson, this volume, Cserer and Seiringer 2009; Gschmeidler and Seiringer 2012; Kronberger et al. 2009, 2012; Lehmkuhl 2011; Pauwels 2009; Pearson et al. 2011). In addition, the importance of past experiences and the drawing of parallels to other research fields, such as biotechnology, nanotechnology, computer science, cloning or stem cell research (Pauwels 2009, 2013; Tait 2009; Torgersen 2009; Torgersen and Hampel 2012; Torgersen and Schmidt 2013), and the role of metaphors like e.g. "playing God", "creating life" (Dabrock 2009; Dragojlovic and Einsiedel 2012; Eichinger, this volume; Falkner this volume; van den Belt 2009), "Frankenstein" (Ball 2010; Gschmeidler and Seiringer 2012; van den Belt 2009) or "living machines" (Deplazes and Huppenbauer 2009) have been investigated in empirical studies and theoretical papers.

What contribution can the Austrian CP study add to the scientific discussion? First, qualitative studies provide the means for exploring public perceptions in-depth and contextualize quantitative data, such as those from Eurobarometer, where Austrians were attested of being particularly cautious about synthetic biology (Gaskell et al. 2010), or from a multi-country comparative survey conducted by Pardo et al. (2009), where Austria ranged at the lower end of 15 investigated societies regarding acceptability of producing biopharmaceuticals in genetically modified animals and plants (Pardo et al. 2009; Rehbinder et al. 2009). Second, by taking qualitative work on public perceptions of synthetic biology conducted in Austria (Kronberger et al. 2009, 2012), in the UK (BBSRC and EPSRC 2010), and in the US (Pauwels 2009, 2013) into account it can be seen if and how attitudes

towards synthetic biology have changed over time and vary between societies. It can especially be investigated if the anchoring of synthetic biology within biotechnology—as stated by Kronberger et al. (2009, 2012) and by Pauwels (2009, 2013)—is still persistent, or if new frames and comparators have emerged. Summarizing, the Austrian CP study which will be presented in this chapter explores questions thrown up by quantitative data, paying attention to discourses and framings of synthetic biology outside of expert and media circles, and to changes in attitudes towards synthetic biology.

2 Methods

2.1 Citizen Panel Methodology

To investigate how members of the Austrian public encounter synthetic biology, citizen panels (CPs) were conducted in this study with participants from a variety of socio-demographic backgrounds.[4] The method of CPs as mode of political participation was developed in the 1970s. CPs were introduced as an innovative method for giving voice to the public and for incorporating its inputs into policy decisions. The idea behind CPs as described by Crosby and colleagues is to put a

> "group of the public in dialogue with public officials so that the officials get the reactions of 'the people themselves' on a particular subject, rather than simply getting the views of those who are lobbying from a particular point of view or interest" (Crosby et al. 1986, p. 171).

However, in the scientific literature, the definition of CPs varies across projects and authors, and a clear distinction from other methods of public engagement seems at times difficult to discern. Rowe and Frewer have criticized the unclear and sometimes contradictory nomenclature of public engagement mechanisms in general (Rowe and Frewer 2005), and their critique also holds true for the CP method. While some authors use the term "citizen panel" synonymously to "consensus conference" (Brown 2006; Guston 1999; Lin 2011), "citizen jury", "planning cell" (Brown 2006; Crosby et al. 1986; Lin 2011), "citizens' review panel" (Fiorino 1990) or "deliberative poll" (Brown 2006), others define each of these mechanisms as different methods for public engagement (Abelson et al. 2006; Nanz et al. 2010; Rowe and Frewer 2005; Sheedy et al. 2008; United Nations Department of Economic and Social Affairs 2011).[5]

[4]The CPs were conducted in the framework of work provided to the Austrian Research Promotion Agency (FFG). The citizen panel study was coordinated and supervised by Herbert Gottweis.

[5]Also the design of CPs is characterized heterogeneously in the scientific literature, which is due to the association of the term with completely different engagement mechanisms (Rowe and Frewer 2005). Accordingly, designs of CPs range from discussions within small groups of participants assumed to represent a specific community (Abelson et al. 2006; Guston 1999; Sheedy et al. 2008), to projects involving several hundred participants constituting a statistically representative sample and having more the form of surveys (Abelson et al. 2003; Nanz et al. 2010). Meetings are

The CP conception of the Austrian study follows a characterization given by Abelson et al. (2006), which is very close to the method of focus groups (Barbour 2008; Bloor et al. 2001; Krueger and Casey 2009; Liamputtong 2011). For Abelson et al. (2006), CPs are composed of small groups of citizens who discuss a predetermined issue in a face-to-face meeting. An expert provides participants with balanced and accessible information on the subject. In addition to being invited to discuss and deliberate on the issue, participants are asked to formulate recommendations based on their deliberations (Abelson et al. 2006, p. 15). Effectively, a CP is here a special kind of workshop with the public, which is composed of information and discussion phases with the aim of bringing different perspectives, ideas and opinions to the fore. As such, CPs are particularly suitable for exploring public understandings of synthetic biology, and for generating inputs for policy making.

2.2 *Sample Design*

For participant selection a purposive, non-representative sampling approach was chosen (Barbour 2014) as the intent was not to produce statistically representative data mirroring the perceptions of the general Austrian population, but rather to get access to different ways of understanding and debating synthetic biology by including the perspectives and experiences of a diverse set of societal groups. The sample was supposed to reflect diversity in terms of age, gender and living area. Men and women involving a mixture of academic grades and professional backgrounds were invited, and participants were divided into two age groups: adults aged 18–49, and adults aged 50+. This separation was chosen on the basis of the hypothesis that in older age groups past experiences with protest movements during the 1970s and 1980s in Austria could have an influence on public perceptions of synthetic biology and its governance.[6]

Participants were recruited during October and November 2012 by snowball sampling and with the help of online advertisements.[7] A total of eight CPs were subsequently conducted—with half of the CPs taking place in Innsbruck, in western

(Footnote 5 continued)

in some cases organized as singular events and in others as a sequence of meetings over a longer time period, with a selected standing group of participants.

[6]In this connection it is important to know about two events that are considered particularly significant for Austria's political culture and popular understanding of protest and democracy. First, during the 1970s a protest movement formed against the activation of the nuclear power plant "Zwentendorf"—ever since, Austria has been nuclear-free in electricity production. Second, in the mid-1980s a protest movement and mass-occupation of the wetland "Hainburger Au" hindered the construction of a hydroelectric power plant in the nature reserve. As a consequence of protester's demonstrations, the natural ecosystem of the "Hainburger Au" has been left untouched until today and Austria's national energy policy deeply influenced by the event (Seifert 2002).

[7]Participant recruitment was carried out by Ursula Gottweis, Walburg Steurer, and Viktoria Veith.

Austria, and half in Vienna, in the eastern part of Austria, so as to account for different regional areas. In each city two groups with 18- to 49-year-old adults and two groups with adults aged 50+ were organized. The number of participants within individual CPs varied from five to twelve people. The overall number of participants was 67. Ages ranged from 18 to 78, with a mean age of 43 years. Overall, there was a small surplus of citizens with higher educational backgrounds due to some participants not showing up on short notice (for details see Table 1).

2.3 Data Collection

All CPs took place in November and December 2012.[8] The discussions were audio recorded with the informed consent of the participants and afterwards transcribed in order to facilitate analysis. Participants were assured that their personal data will be treated confidentially and their statements remain anonymous. Each CP lasted for about two hours and was led by two trained moderators who provided balanced information about synthetic biology and ensured that every participant had equal opportunity to speak. For the moderation of the CPs, a semi-structured topic guide, composed of five thematic units, was followed. The same topic guide was used in every CP for comparability of results. Each thematic unit was divided into two alternating phases: (1) information phases in which participants received information about objectives, strategies and fields of application of synthetic biology, and (2) discussion phases in which participants were invited to bring in their perspectives and opinions on synthetic biology, to discuss challenges and opportunities within the group and to formulate recommendations on synthetic biology governance.[9]

The CPs started with an introduction by the moderators and the disclosure of the topic to be discussed. In order to avoid that participants inform themselves beforehand, when inviting them, they had been told that the CPs would be about the role of science and technology in general, and about a novel research field to be disclosed during the CP in particular. Therefore—and as a warm-up exercise—in the first thematic unit participants were invited to discuss the impacts of science and technology on their everyday lives.

Within the second unit, participants were provided with basic information about functioning of cells, genome, and genetic blueprint, and the ways in which synthetic biology uses, (re-)constructs, and (re)designs them by combining the knowledge and practices of biology, chemistry, physics, engineering and information

[8]The CPs were organized and conducted by Ursula Gottweis and Walburg Steurer.

[9]Regarding the composition of the thematic units and selection of example cases the topic guide was inspired by those used in the UK "Synthetic Biology Dialogue" by BBSRC and EPSRC (2010) and in the public dialogue organized by the Royal Academy of Engineering (2009). Furthermore, case selection was inspired by a focus group study conducted by a group of researchers from the Chair of Ethics at the Friedrich-Alexander University Erlangen-Nuremberg, which is yet to be published.

Table 1 Characteristics of sample

		Number (n)
Number of citizen panels		8
Number of participants		67
Gender	Male	38
	Female	29
Living area	Innsbruck	36
	Vienna	31
Nationality[a]	Austria	33
	Other	26
Age	18–49	36
	50+	31
	Average age of 18–49 year olds	30
	Average age of 50+ year olds	62
	Age range of total sample	18–78
	Average age of total sample	43
Educational level[b]	Basic education	9
	Vocational education	11
	Secondary education	23
	Tertiary education	36
Employment status[b]	Student	27
	Employed	24
	Freelance	8
	Unpaid work	3
	Unemployed	3
	Retired	19

[a]Not specified by 8 participants
[b]Multiple answers possible

technology. Further, it was explained in how far synthetic biology is different from traditional genetic engineering. This first information phase was followed by a discussion about participants' understandings and interpretations of the term "synthetic biology" and about its ethical, legal, social and economic implications.

The third thematic unit was dedicated to possible applications and products of synthetic biology. The moderators presented examples from three different fields of application: (1) Medicine: Synthesis of artemisinic acid—a precursor substance for the anti-malarial drug "Artemisinin"—in redesigned yeast. Traditionally, the substance is extracted from the sweet wormwood tree (Artemisia annua) cultivated primarily in China, Vietnam, Kenya, Tanzania, Uganda, Madagaskar and India. Stakeholders promise that with the help of synthetic biology production costs could be reduced and access to the drug for less developed countries be guaranteed (Collins 2012; Hommel 2008; Keasling 2009; Ro et al. 2006; Weber and Fussenegger 2009; Westfall et al. 2012). (2) Agriculture: Construction of modified

organisms (bacteria, viruses, or insects) for plant pest control (Gilbert and Gill 2010; Jin et al. 2013; Thomas et al. 2000; Weber and Fussenegger 2009). The main arguments advanced by researchers for supporting this kind of research is that the use of pesticides and potential impacts on human health could be reduced through this biological alternative, and that non-target species would remain untouched by the artificially constructed organisms (Jin et al. 2013; Weber and Fussenegger 2009). (3) Environment: Bio-fuels from redesigned algae as an alternative for fossil fuels and biofuels from crops (Georgianna and Mayfield 2012; Gimpel et al. 2013; Service 2011; Wang et al. 2012). Each presentation was followed by a discussion about the application of synthetic biology in that specific case, and possible challenges and opportunities. Participants were invited to reflect as well about positive as about negative implications.

In the fourth section, questions were asked concerning the governance of synthetic biology. Focus was drawn to the role of researchers, policy makers, and funding bodies. Participants were asked to give recommendations on how the field should be regulated, who should regulate it, and how supervision could be guaranteed. Furthermore, they were asked about requirements that should be met for research funding and about conditions for synthetic biology products to enter the market.

Finally, participants were invited to imagine a future where synthetic biology would be part of their everyday lives, and to describe their imaginations, expectations, and feelings, such as hopes, fears and concerns.

2.4 Data Analysis

For data analysis, a mixed methods approach combining structured content analysis (Kuckartz 2012; Mayring 2008) and interpretive frame analysis was chosen (Fischer 2003; Schön and Rein 1994). Structured content analysis allows for combining inductive and deductive approaches in category development, and is furthermore suited for coding manifest as well as latent contents within texts (Kuckartz 2012). Consequently, in the first step of the analysis, key issues were identified and a category system developed. This was based on the thematic structure of the topic guide and on prior knowledge gained from the scientific literature. After coding about 20 % of the data material, categories and codes were revised and new ones formulated inductively as they emerged from the empirical data. The analysis focused on manifest contents as well as on in-depth structures and latent contents within the transcripts. Frame analysis allows to analyse underlying frames that shape discourses (Fischer 2003; Schön and Rein 1994). By conducting frame analysis special attention was put on the framing of synthetic biology by the CP participants and on comparators chosen for making synthetic biology graspable. Throughout the whole project, the use of the qualitative data analysis software Atlas.ti facilitated the management, storage and organization of the data (Friese 2012).

3 Results

3.1 *Something Old, Something New—Making the Unknown Tangible by Drawing Parallels*

The majority of the participants was not familiar with the term "synthetic biology", even though they knew about the practice of (re-)constructing organisms in laboratories with the help of modern technologies. Thus, while the practice itself was known, participants did not associate it with the term "synthetic biology".

Generally, the term "synthetic biology" evoked surprise and puzzlement. This was due to the combination of the two words "synthetic" and "biology", which were understood as being opposed to each other. In order to make sense of the "contradictory" concept, participants on the one hand looked at each of the two words separately, and on the other, at the relation between them. They often concluded that the term "synthetic biology" was a contradiction in itself: "synthetic" as something artificial, unnatural, technical or man-made, and "biology" as something natural, living, and detached from human power. Participants put it as follows:

> That's a contradiction. Synthetic biology is a contradiction. 'Bio' is a Greek word, as far as I remember from school, and it means, means '*life*', but *synthetic life*, I am not sure, if you can call this life at all.[10]

> Participant (P) 10: It's a paradox, when I only see these two words, 'synthetic' and 'biology'. I associate 'biology' automatically with a natural product and 'synthetic' is just its opposite.
> P11: Well, but what *is* nature? […] *Nature* is itself only a construct made by man, hum, something he invented, created somehow.[11]

Statements of this type led to discussions about the definition of "life" as such. While for some the main concern lay in drawing a demarcation line between "dead matter" and "life", "artificial" and "natural", or "animate" and "inanimate", others classified the word "synthetic" as simply not being appropriate to describe neither the "material" from which parts and systems are constructed nor the organisms resulting thereof. Single components as well as "life forms" constructed by synthetic biology were perceived as being built from living substance, not from dead material or scratch—as the word "synthetic" would suggest—even though the constructed parts, systems and organisms do not exist in nature and presumably would never have been generated by it. In the words of a participant:

> There must already have been something living within it, living organisms can't be built from dead matter.[12]

[10]Male participant in CP 8, adults aged 50+, Innsbruck.

[11]Conversation between two male participants in CP 6, adults aged 18–49, Innsbruck.

[12]Male participant in CP 1, adults aged 50+, Vienna.

Furthermore, imaginations and meanings of the attribute "synthetic" from other contexts and shared discourses were mobilized. It made people think of synthetic foodstuff, such as "imitation cheese" and "imitation ham",[13] energy drinks and E-numbers. The word "synthetic" was associated with something "lab-grown", "unhealthy" and "faked". To sum it up, the term "synthetic biology" caused irritation and evoked rather negative yuck feelings and imaginations. Noteworthy in this context is the following comment:

> Err, but in general, for me, this term, I mean synthetic biology, sounds, err, is negatively loaded, err, um, err, because it is, err, I think there are so many dangers that could come up within science. And for me this sounds a bit like, like certain science fiction novels I have read, and they seldom had a happy end.[14]

Beyond reflections about the literal sense of the term "synthetic biology", participants also tried to make sense of the practices and consequences of synthetic biology by drawing parallels. This can be interpreted as strategy to cope with the unknown and uncertain: by comparing the abstract with the concrete, the former becomes tangible and understandable. In the CPs especially the imagined challenges and opportunities of synthetic biology were compared to experiences with scientific innovations from throughout the history of humankind, as the next quotes show:

> There we are in a similar situation as Marie Curie was, who did research into uranium, had uranium all over her body, and died from it. But, can we put into question that it was a breakthrough? Didn't it generate fundamental knowledge for contemporary science?[15]

> A little bit it reminds me of the time when the steam engine, the steam locomotive was invented, and then also people were against it, and for heaven's sake, devil's work, and dangerous, you die when you move so fast. Ah, it's the *uncertainty*.[16]

> But you could see it also with drugs, that many drugs, starting with Contergan,[17] till I don't know, many drugs have been released, that afterwards had completely different side-effects, we should treat it with caution, the whole thing.[18]

While the examples cited above refer to historical events, parallels were also drawn to more recent phenomena and empirical values from neighboring research fields, such as nanotechnology, information technology, pre-implantation genetic diagnostics, stem cell research or cloning. However, the most common reference made was to genetic engineering—with a tendency to equate synthetic biology and

[13]These terms are known in German under the buzzwords "*Analog-Käse*" and "*Mogel-Schinken*", which had been at the centre of heated public debates throughout the previous five years (Die Welt 2009).

[14]Male participant in CP 2, adults aged 18–49, Vienna.

[15]Male participant in CP 6, adults aged 18–49, Innsbruck.

[16]Male participant in CP 7, adults aged 50+, Innsbruck.

[17]Contergan was the trade name of a drug containing thalidomide, which was freely available in pharmacies in Western Germany from 1957 to 1961. It was, amongst others, used against morning sickness in pregnant women, and caused severe damage to children, most notably with regard to limb development.

[18]Female participant in CP 5, adults aged 18–49, Innsbruck.

genetic engineering or to understand synthetic biology as the obvious and logical progression of genetic engineering. This becomes clear from the citation in the introduction to this chapter as well as from the following excerpt:

> But on the other side, the risks and opportunities that emerge out of this new, or maybe not so new technology are old hat. It was thirty years ago, if you think about what lies ahead, for example with genetic engineering, I don't see any difference with my lay knowledge. If you do it this way, or that way, it's all, there are incredible opportunities, but there is also an incredible amount of things that could fall on us.[19]

In summary, participants tried to make sense of synthetic biology and its implications by drawing parallels to other technologies and past experiences. The fields associated with the (re-)construction of organisms were preferably inscribed within the discursive frame of "genetic engineering" or "genetic modification". Furthermore, the term "synthetic biology" caused irritation and evoked rather negative feelings and expectations. Therefore, the next section will focus on concrete dangers and challenges brought to the fore by CP participants and on the hopes and opportunities they perceived within "this new, or maybe not so new"[20] research field.

3.2 *Something Good, Something Bad—"An Ambivalent Thing"*

In order to further investigate risks and opportunities of synthetic biology, participants were introduced to three examples for its (future) application and asked to discuss positive and negative aspects for each example.

The first example presented was the application of synthetic biology for the production of artemisinic acid in modified yeast. Other than the high hopes and promissory future scenarios raised by scientists and stakeholders, attitudes towards the synthetic Artemisinin were divided in the CPs. While some participants showed enthusiasm, others were more cautious and pointed to unknown risks and economic interests. This ambivalence becomes apparent in the following conversation:

> P11: I think, finally something happens, because down there [in Africa], where people are really poor, in an economic sense, they could really be helped, with this drug at a cheap rate. So, I really appreciate and support it, and I say 'it's a good thing'. But the question is always who really takes profit. Those, who receive the treatment, or again a big company, or companies? But we will never be able to prevent this.
> P9: No, but principally, if an effective drug against Malaria can be produced, we can only appreciate it.[21]

[19]Male participant in CP 1, adults aged 50+, Vienna.

[20]Male participant in CP 1, adults aged 50+, Vienna.

[21]Conversation between two male participants in CP 8, adults aged 50+, Innsbruck.

After initial fascination, people were primarily concerned about the interests of (pharmaceutical) companies and industries behind the research. Throughout all CPs, the topics of monopolies, intellectual property rights and distributional justice constituted issues of discussion. One participant cited the example of drugs against AIDS to underpin his concern that access to novel products and scientific achievements would remain a privilege of the rich. He argued that multinational companies would hold patents and prevent large-scale supply with drugs at an affordable price for the poorest countries.

Other comments focused on the future of the farmers who cultivate the medicinal plant from which the artemisinic acid is traditionally extracted:

> Will they in the future have a means of existence?[22]

Furthermore, in two CPs, participants voiced suspicions about the selection of the Artemisinin-case for the CPs. In their perception the Artemisinin-example could be misused as a door-opener argument for the application of synthetic biology in other fields:

> You have chosen an example that is effective as good publicity for synthetic biology. Because against Malaria, we know it, something has to be done, because hundreds of thousands of people are dying of it, maybe more.[23]

Beyond economic interests, uncontrollability and uncertainty mattered to participants. In particular, they were concerned about long-term risks and side effects. Participants pointed out that research was still at an early stage and worried that consumers could be used as "human guinea pigs". Furthermore, participants questioned what would happen if the modified yeast would "escape" from laboratories and crossbreed with natural organisms. It was argued that unintended evolution and mutations could be the consequence and the sensitive balance of natural ecosystems be damaged. Several participants invoked Goethe's ballad "The Sorcerer's Apprentice" or Shelly's "Frankenstein" to epitomize their visions of a future with synthetic biology.

Concerns about uncontrollability were even more pronounced in the second example case: the construction of bacteria, viruses or insects for plant pest control. Again long-term impacts and unforeseeable side effects were perceived as critical. Participants pointed to the risk of crossbreeding between natural and artificially constructed organisms and misuse of synthetic biology for terrorist purposes and warfare:

> P6: I would have a bad feeling with this thing, that this, that they could somehow mutate and become killer viruses [generalized laughing, talking across each other], yes
> P1: extremely
> P3: that's really how it is
> P6: and to me, to my mind there are always and immediately coming weapons
> P1: chemical

[22]Female participant in CP 5, adults aged 18–49, Innsbruck.

[23]Male participant in CP 8, adults aged 50+, Innsbruck.

P3: Anthrax
P6: yes, chemical, [talking across each other] I really wouldn't need that
P3: No, me neither, I don't want that
P1: Me too, I am rather, yes, quite skeptical, against that. I would also be scared that someone could say (..), yes, because, we always believe, man always nicely believes, that he can control everything, but
P2: we often saw that
P1: that it went wrong.[24]

Taken together, also in the agricultural field participants' attitudes towards the application of synthetic biology were marked by perceptions of risks and distrust in authorities and scientists to overlook the field. Compared to the medical field, risk perceptions and fears were much more pronounced in agriculture, as participants imagined the use of synthetic biology for medical purposes in laboratories or as drugs within the human body as less problematic than field release of novel organisms in open environments. Their reasoning was that in the first case controllability could to some degree be possible due to research taking place within confined spaces, while uncontrollable evolution and mutations were perceived as being the logic consequence of field release of novel organisms into natural ecosystems. In addition, it is notable that parallels to past experiences with genetically modified crops were again drawn:

I don't know, I am rather skeptical about interventions within the natural ecosystem. I think it's a completely different thing if you do it only, only in the medical field. I think in the medical field I am much more tolerant and I think, there you can try much more, but when man impinges on nature, which is not a human being, but algae or insects, I simply have a bad feeling, and I don't think that we can control everything like we suppose to do, because also when you just use it within confined areas - they did it as well with genetically modified maize, which was spread by the winds, and, I don't know, I simply have a bad feeling.[25]

A second example further illustrates the embedding of synthetic biology within the discursive frame of genetic engineering and the mobilization of respective imaginaries:

P1: […] There's again a danger connected to it. How should it be possible to test it? It's difficult to say, because there exist a huge variety of bacteria and viruses, and, and all these things are so huge. I think you can't test it, you simply have to apply it (.) with force, stop, punctum.
P11: That would mean almost additionally to genetic manipulation, right? If there is some vermin in maize, and now if […] I would culture a virus, which fights that particular vermin, and then we do genetic engineering
P1: all inclusive
P11: [laughs cynically] yes. But I think a layperson lacks the overview. How can this really be done within boundaries?

[24]Conversation between two male (P1, P2), and two female (P3, P6) participants in CP 5, adults aged 18–49, Innsbruck.

[25]Female participant in CP 4, adults aged 18–49, Vienna.

> P1: Right. Is science able to assess the risks? Or how much time do such trials take, to have at least a minimum of security? That's alarming, isn't it?[26]

Overall, in both example cases—medicine and agriculture—distrust against authorities, scientists and sponsors of synthetic biology seem to be at the heart of participants' skepticism. Distrust became visible not only when participants questioned the possibility to control or overlook the field, but also when they communicated their suspicion that those interested in the research would obscure their "real" aims and interests—thus, participants perceived a fundamental lack of transparency. A similar distrust had already become apparent with the suspicion that the Artemisinin-example could be used as door-opener, but it became even more apparent when participants put into question the arguments that by using synthetic biology, arable farm land could be saved for food production and thereby the growing world population be fed.

Along this line of distrust, in the third example case—the production of biofuels from redesigned algae as an alternative to fossil fuels or biofuels from crops—participants criticized a perceived instrumentalization of the issue of "hunger" or of the argument of "ensuring food supply for the growing world population" for the promotion of synthetic biology. Further, participants were suspicious that other energy sources would intentionally remain unexplored and research left without funding due to economic interests. The next quote illustrates this generalized distrust:

> I don't think that bio-algae are the solution, don't think that this will become commonplace, impossible for me, honestly, to be perfectly honest. I worked in the automobile industry for twenty years, I know that there was research going on in the past; with steam you can power cars, in principle that doesn't cost anything, but those in power are against it, they hinder that these things enter the market, because everything would collapse, it's determined by money, and power, and avarice, but that's the world.[27]

Within the pattern of distrust and skepticism moral questions played a critical role, as they again displayed participants' pessimistic and suspicious attitude towards synthetic biology. Participants were not only critical about the construction of "life" as such, but worried also that optimization and purposeful selection could easily be drawn into extremes. They argued that synthetic biology would begin with the (re-)construction of bacteria, insects, or algae, but in the future could be used for eugenic purposes with the aim of constructing the "perfect human". While the question of how far man is allowed to go and the reproach of transgressing nature were mentioned several times, interestingly the metaphor of "playing God" was only used twice. This may be due to a perception of synthetic biology as not being something completely new, but another form or a progression of classic genetic engineering, and as such something which has become "normal" or perceived as being within the realm of humans' mighty.

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[26]Conversation between a female (P1) and a male (P11) participant in CP 8, adults aged 50+, Innsbruck.

[27]Female participant in CP 3, adults aged 50+, Vienna.

Summarizing the inputs, the application of synthetic biology was perceived as "an ambivalent thing" with hopes, fears, and moral concerns openly voiced in the CPs. In addition, distrust could be identified as a central attitude towards synthetic biology. An excerpt brings this exemplarily to the point:

> P9: But it's an ambivalent thing. On the one side there are many risks and dangers, on the other science and technology have made an increase in life expectancy possible. […] I would say 'boon and bane', right, both.
> […]
> P6: But in the end it's always man who is responsible, will it be good, or will it be bad.
> P2: For sure.
> P6: So we should try to control him [man].
> [Laughing]
> P5: But maybe it could be like with the atomic bomb. Someone too invented that, I think, and only afterwards he realized how deadly it was. Many might not even know what will be the end product.[28]

This ambivalent image raises questions about how participants cope with the perceived uncertainty and intransparency, and which attitudes they developed out of their distrust and skepticism. The answers to these questions will be provided in the next section.

3.3 Being "Just a Lay Person"—Between Resignation and Self-Activation

The attitudes that participants developed as a result of their distrust were—like distrust itself—mostly not expressed directly, but became discernible as implicit attitudes within discussions. Two major attitudes—understood as coping strategies—could be identified: resignation and self-activation. Resignation comprises on the one hand the perception of oneself as being "just a lay person" who lacks the overview and is obliged to believe what scientists—perceived as "insiders"—and the media say, and on the other hand, the feeling of being powerless, to have no influence on the progress of science. Concerning the latter, participants voiced first, the fear that research would continue anyway, independently of peoples' demands, wishes and opinions, and second, the feeling of being powerless against (economic) interests:

> P5: Well, science will always move on, regardless of whether you are for or against it, whether it's forbidden or not, it will go on. But I'm not doing well with that, so.
> P1: In the course of years, technology will maybe have progressed so far, that a normal, a mortal individual won't be able to manage it, right?[29]

[28]Conversation between a female (P5) and three male (P2, P6, P9) participants in CP 8, adults aged 50+, Innsbruck.

[29]Conversation between two male participants in CP 7, adults aged 50+, Innsbruck.

> The fact that this drug [Artemisinin] does already exist, demonstrates that regardless of what we are discussing here, it has already been done.[30]

> […] my estimation is realistic, it's not preventable. All that's imaginable, all that's researchable, will be researched, if not now, then in 10 years, it's a stream that is in a state of flux. They will try to regulate it as good as possible, but they will fail.[31]

However, distrust and the feeling of powerlessness did not only result in resignation, but in some participants turned into its opposite: an attitude of self-activation. Self-activation in this context means a form of emancipation of the individual, who becomes aware of his/her power as critical and self-reflexive consumer. Accordingly, participants defined it as crucial, first, to inform themselves very well, for example by reading food labels attentively, in order to be empowered as individuals to decide which products to buy. Second, it was seen as essential to rethink one's consumer behavior on a more general level. This included self-criticism of being members of a "throw-away-society" which incites a run for the cheapest products regardless of the conditions of production, as well as very concrete suggestions like the reduction of individual car use, which would make the need for alternative energy sources—and therefore also research into biofuels from redesigned algae—less urgent. Thus, self-activation emerged as a defense reaction against a general distrust in scientists, industry, funders and regulators, and against a perceived non-transparency, manipulation by media and advertisement, and an imbalance of power between "insiders" and the "lay public".

Finally, the call for individual responsibility was further expanded into a call for societal responsibility, especially for the next generations. This brings us to the question of how synthetic biology should be regulated.

3.4 The Big "If"—Setting the Conditions

The overall impression gained from data analysis is that support for synthetic biology is always conditional. Thus, especially—but not only—when CP participants were asked about preconditions for the application of synthetic biology and recommendations for its governance, there appeared a big "if". This big "if" could be identified as a recurring pattern within different contexts.

The first big "if" concerned information and transparency and was therefore closely related to the distrust identified before. In the preceding section, the importance of informing oneself and taking the role of the responsible consumer was addressed within the pattern of self-activation: the labeling of products in a clear and visible manner had high priority for most participants as it symbolizes the guarantee for being oneself the person who decides what to consume. Thus,

[30]Male participant in CP 6, adults aged 18–49, Innsbruck.

[31]Male participant in CP1, adults aged 50+, Vienna.

information and transparency were established as preconditions for autonomy and for the restoration of trust in authorities. An excerpt illustrates this well:

> We can't stop it from progressing anyway. It's happening in the background anyway, all that research does already exist, I don't know for how many years, but research continues, it will come anyway. But there must be someone who communicates that in a hundred per cent transparent way to the people, what exactly happens there, what are the negative sides, what is positive about it. So, I really would like to be informed very well, then I can decide for myself, if I want to buy it or not, that's the point.[32]

The quote is interesting in two dimensions: On the one hand, it highlights a shift from resignation to self-activation, on the other, it shows that knowledge—gained through information—symbolizes and enables a form of power as it facilitates the emancipation of the individual. Hence, it can be concluded that transparency and information, first, help to restore the balance of power between informed "insiders" and "lay people", and second, to restore trust in authorities.

The balancing of risks and benefits constituted a second big "if". Participants underlined that uncertainties should be disclosed from the outset. An excerpt illustrates the importance of knowing challenges and opportunities of synthetic biology—thus, again, the importance of transparency—and of having the possibility to choose:

> Well, if I could say from the beginning 'these are the opportunities and those are the risks', put all I know on the table, then I could maybe better form my opinion than if I always have the feeling that we are manipulated, only the advantages, only the advantages. And about the risks I have to think on my own.[33]

Within the context of balancing risks and benefits, the exploration of alternatives was perceived as critical. The big "if" here refers to missing alternatives and a perception of synthetic biology as being the lesser evil. Thus, if no alternatives are available, synthetic biology becomes a viable practice. The following conversation taken from a discussion about biofuels from redesigned algae shows this well:

> P2: The question is, so it seems to me, if we want to continue pumping up fossil fuel from the soil, or if we want to extract it from algae.
> P1: I believe that there must be an *alternative*. I simply cannot imagine that there doesn't exist *anything*.
> P2: Me neither, I don't find any of the two possibilities cool, but if you have to take a decision,
> P1: yes, then algae would in any case be the lesser evil. Now, I have to admit, that it *is* no bad idea.
> P2: That's a technical question.
> P2: Well, it's no bad idea, but (..)[34]

[32]Male participant in CP 3, adults aged 50+, Vienna.

[33]Female participant in CP 1, adults aged 50+, Vienna.

[34]Conversation between a female (P1) and a male (P2) participant in CP 6, adults aged 18–49, Innsbruck.

Missing alternatives were a decisive factor for the support of synthetic biology particularly within the medical field—the field of application that received most support within the CPs. Thus, if the question is about life and death, the ways how drugs are produced play only a minor, if any role at all, as the next quotes demonstrate:

> P4: If I were affected by a certain disease, I would be happy if drugs were available, regardless of whether they are produced with the help of synthetic biology, or not, I would not care about that.
> P1: Yes, if they could help you, right?
> P2: Year, that's
> P1: that's clear, yes
> P4: Then I would be happy, if something would exist, then.[35]

> P3: I think, and this is very interesting, when it comes to physical health, our attitudes change completely [affirmation from other participants] regarding those things. So, I think if I suffered from Malaria and had no money and could get this drug, at a cheap rate
> P1: then you would take it
> P3: cheaper, I would buy it
> [Several participants speak simultaneously, incomprehensible]
> P3: it's something completely different
> P6: of course.[36]

The cost factor was, thus, decisive for the support of synthetic biology. This was not only true for the medical field, but also for other fields of applications, such as agriculture:

> Sounds promising, especially in regard of fuels, if it can really be produced at a cheaper rate.[37]

Third, prevention and containment were named as pivotal requirements. Participants recommended that long-term studies and reliable tests on side effects should be carried out before synthetic biology products enter the market and before modified organisms are released into natural ecosystems. Furthermore, it was requested that agents for drugs should one-to-one correspond to agents extracted from natural sources, and research and application of synthetic biology should remain within confined spaces or closed areas. The scientific literature differentiates between "biosecurity" as prevention of intended harm (e.g. bioterrorism), and "biosafety" as prevention of unintended harm (e.g. natural disasters) (Kelle 2009); these concepts could also be identified within the CP discussions, even though participants did not use these terminologies. To give a few examples, participants' recommendations sounded as follows:

[35]Conversation between a female (P2) and two male (P1, P4) participants in CP 7, adults aged 50+, Innsbruck.

[36]Conversation between a male (P1) and two female (P3, P6) participants in CP 5, adults aged 18–49, Innsbruck.

[37]Male participant in CP 5, adults aged 18–49, Innsbruck.

> Well, yes. I imagine that this could be a great thing, if it were safe, whereas safety is a two-edged sword. What might seem safe to one person might seem unsafe to the other. But there are lots of things that should be tested, and checks that should be implemented.[38]

> P11: I could imagine that, if research would really engage this intensively, so that they could also manage to control the side effects.
> P6: Year, year.
> P11: If they could say 'it will only do this, and, and, nothing else'.[39]

> I think as long as it's within confined spaces or something, like it's with this drug [Artemisinin], I don't know, I wouldn't have any problems with it.[40]

> I think it would be good to know how things work, just in case. It should only be used within confined spaces. So, my fear is rather, that this falls in the hands of the wrong decision makers, who could lead us into a world wherein we would not want to live.[41]

Finally, participants were asked how and by whom these "ifs" could be met, i.e. how the field should be regulated, who should regulate it, and who should be responsible for its oversight. A broad variety of recommendations were given, but opinions were divided. While some participants argued that research and application of synthetic biology should be regulated by each state individually, others were more inclined to regulation at international level. Alternatively, it was proposed that an independent regulatory and supervisory body should be created—be it at national or at international level. Still others argued that existing regulations on biotechnology would be sufficient for regulating synthetic biology.

On the other hand, there were participants who questioned the possibility of regulation in general. They argued that both, policy makers as well as scientists would be corrupted and that only in a utopian world regulation and control could be possible. Participants explained that when money comes into play regulation and control would be an illusion, because on the one hand there would be an entanglement between economy and politics, and on the other between economy and scientific research:

> Even though this might sound radical, when economy gets into the game it always becomes a little bit corrupted, and at that moment morals do not play a role anymore, then it says 'profit or not'; and in a perfect world you could separate it, there you could say 'here is the research and everything happens for the common run of mankind, and there is the market', but it's a healthcare industry, and not everything is love, peace and harmony.[42]

The citation entails two central messages: first, it sets the fourth big "if", in that it implicitly points to distributional justice and equal access to benefits arising out of synthetic biology as preconditions for research in synthetic biology. Second, it contains the assumption that the entanglement between research and economy and between research and politics also means that researchers cannot be trusted.

[38]Male participant in CP 8, adults aged 50+, Innsbruck.

[39]Conversation between two male participants in CP8, adults aged 50+, Innsbruck.

[40]Female participant in CP 2, adults aged 18–49, Vienna.

[41]Female participant in CP 4, adults aged 18–49, Vienna.

[42]Female participant in CP 4, adults aged 18–49, Vienna.

As such, the option of having the conscience of researchers as guiding principle or regulatory mechanism—as proposed by some participants—is also implicitly rejected. In some CPs this option was even explicitly rejected, for example, when participants argued that conscience of researchers would not suffice for regulation because it would depend on each subject's point of view and personal standards for integrity could vary between researchers.

Summarizing, CP participants had very clear ideas about the preconditions that should be given in order to guarantee responsible research in synthetic biology and safe applications, even though there was no consensus about who exactly should regulate and control the field. Most notably, while there were manifold and diverging opinions regarding the latter question, there was one shared opinion: that citizens should be given more voice within synthetic biology governance.

4 Discussion and Conclusion

Incorporating citizens' views by, for example, taking the openly stated opinions and recommendations—as well as the implicit attitudes—of the Austrian CP participants seriously could make research and governance of synthetic biology more socially robust. Interestingly, in the present study, differences due to age groups, gender, or educational and residential backgrounds were almost not found. Only the attitudes towards the application of modified organisms in agriculture and the investigation of alternatives to fossil fuels and biofuels from crops seemed more affirmative in the Innsbruck CPs. Overall, similarities between groups outweighed differences, which is contrary to our original hypothesis, which was that past experiences with protest movements during the 1970s and 1980s could play a role in elder generation's discussions.

The analysis showed that CP participants' awareness of synthetic biology was rather low when they were first confronted with the term. This low level of awareness was no big surprise, as it corresponds to Eurobarometer data from 2010, where 83 % of respondents across the EU member states declared that they had not heard about synthetic biology yet (Gaskell et al. 2010, p. 30). Interestingly, however, despite not knowing the term "synthetic biology", CP participants were well aware of the practices that are used in synthetic biology and of research going on in that field. Therefore, the CP results raise the question of whether respondents interviewed for the Eurobarometer survey were not aware of synthetic biology research or whether they simply were not familiar with the term.

Overall, the results of the Austrian CPs did—with regard to manifest contents—not differ significantly from the results of the "Synthetic Biology Dialogue" set up in the UK by BBSRC and EPSRC (2010), and the focus group studies conducted by Kronberger et al. (2009, 2012) in Austria and by Pauwels (2009, 2013) in the US. Issues identified as critical within those studies, and in the scientific literature more generally, did also come up in the Austrian CPs: risk-benefit-tradeoff, biosecurity, biosafety, economic interests and intellectual property rights, equal access,

definitions of life and moral questions concerning the construction of artificial life, lack of information and transparency. Also, the difficulties in distinguishing synthetic biology from traditional genetic engineering and the embedding of practices of (re-)constructing organisms or their parts within the discursive frame of "genetic engineering" were clearly visible in the CPs.

However, what differentiates the Austrian CPs from the other three engagement experiments is that distrust seems to be much more pronounced. Distrust became first and foremost discernible when looking at the in-depth structure of the textual material. It became manifest in a sceptical and rather pessimistic fundamental attitude, with participants underlining the ambivalent character of synthetic biology and voicing suspicions about the "real" interests behind research. This threw up the question how participants cope with their distrust, and led to the subsequent identification of two main coping strategies. While on the one hand, resignation could be identified as one possible coping strategy, on the other hand, people tended to call upon individual responsibility. For example, participants suggested reconsidering their own life style in the context of their appeal to rethink consumer behaviour. Nonetheless, CP participants had the clear understanding that emancipation is only possible when "insiders"—understood as the synthetic biology community, regulators, and the media—provide information to the public. Comparison with the BBSRC/EPSRC study shows that participants' feelings of powerlessness to understand the science or to have any influence on scientists point to similar attitudes of resignation (BBSRC and EPSRC 2010, p. 41), whereas the call for self-activation seems to be rather specific to the Austrian CPs.

Furthermore, while participants acknowledged positive sides of synthetic biology as well and voiced high hopes, support for synthetic biology was always conditional. Within the pattern of setting conditions, four big "ifs" could be identified as being essential for acceptance of synthetic biology. These were: (1) information and transparency, (2) the balancing of risks and benefits and the investigation of alternatives, (3) the application of synthetic biology only within confined and controlled spaces and after thorough testing (biosecurity and biosafety), and (4) equal access to products and benefits. The big "ifs" were often uttered implicitly and seem to rely on unconscious constructions that are influenced by past experiences and empirical values from other fields. Thus, the construction of the big "ifs" is related to the attitude of drawing parallels. Drawing parallels can be interpreted as a strategy to make the uncertain and unknown tangible and understandable—a process in which past experiences and empirical values offer a repertoire of imaginaries for developing visions for the future. Drawing parallels and referring to past experiences was also identified in the UK public dialogue (BBSRC and EPSRC 2010), and in Austrian (Kronberger et al. 2009, 2012) and US focus groups (Pauwels 2009, 2013).

The imaginative repertoire which was most prominently mobilized when drawing parallels was that of genetic engineering. It can thus be concluded that the fields associated with the (re-)construction of organisms are occupied by the discursive frame of "genetic engineering" and "genetic modification". This perception of synthetic biology as not being something completely new, but another form or a

progression of traditional biotechnology may also explain why the metaphor of "playing God"—which the author had expected to come up frequently as it is often taken up by the media—was pronounced only twice. It seems that the manipulation and construction of living organisms was rather perceived as something man had done for years and therefore not as a skill solely ascribed to God or nature. It is noteworthy in this context that also in the BBSRC and EPSRC (2010) and the Kronberger et al. (2009, 2012) studies the "playing God" metaphor seemed not to matter in the first place. However, this paralleling between synthetic biology and genetic engineering, and the perception of synthetic biology as being within humans' mighty does not mean that synthetic biology is perceived as something positive—rather it is understood as being even worse than genetic engineering in that it goes "one step further".[43]

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