

PROJECT FINAL REPORT

Grant Agreement No: 321488

SYNERGENE

Synthetic Biology – Engaging in Responsible Governance of New and Emerging Science and Technology in Responsible Governance of the Science and Society Relationship

Funding Scheme: FP7-CSA-SA
Period covered: 01/07/2013 - 30/06/2017
Version: [V1.2]
File name: [SYN-ENERGENE_Final_Report.pdf]
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Document Info

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This document should be referenced as	Christopher Coenen (2017): Final Report SYN-ENERGENE, co-funded by the European Union under the 7 th Framework Programme, Karlsruhe, Germany

Ver- sion	Issue Date	Distribution	Changes made/ comments	Draft (D) vs. final version (F)
1.1	16/08/17			D
1.2	17/08/17			F

Dissemination level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
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1 Final publishable summary report

1.1 Executive Summary

Synthetic biology (SynBio), “the engineering of biological components and systems that do not exist in nature and the re-engineering of existing biological elements”, signals a new area of research and development in the life sciences. It raises questions in the context of responsible research and innovation (RRI) relevant to many different stakeholders, policy makers and the general public. Running from July 2013 to June 2017, the SYNENERGENE Mobilisation Mutual Learning Action Plan (MMLAP) mobilised a wide variety of stakeholders and members of the public, bringing them together and facilitating an open-ended, sustainable and fruitful dialogue with a view to promoting societal discourse on SynBio. Designed as an open outcome process, SYNENERGENE operated as a large-scale and innovative ‘science in society’ activity dealing with an emerging field of science and technology in a European RRI context, with a high degree of international visibility and a wide variety of impacts on societal discourse on SynBio and the related innovation trajectories. SYNENERGENE has carried out more than 120 single events as planned, and additionally, thanks to its flexible approach, a plenitude of other activities, including many conducted at the initiative of and in cooperation with external partners. While a wide variety of public participation and outreach activities took place in SYNENERGENE, often at a local level, whose results were subsequently fed into other activities of the project, the other important focus of SYNENERGENE was on stakeholder activities and interaction. Among the specifically addressed stakeholder and other groups were artists, civil society organisations (including faith-based groups and organisations), the do-it-yourself biology (DIYBio) and biohacking community, education professionals, industry representatives, natural scientists and engineers, policy makers, science journalists, and young people (e.g. students from a wide variety of fields, including the iGEM community). In line with its work plan, SYNENERGENE allowed many of these stakeholder groups to develop their own strategies, but at the same time organised or supported multi-stakeholder interaction, also in public settings. One key feature of the SYNENERGENE project has been the fostering and use of art-science interfaces in which these were mainly conceptualised as means of an exchange involving two different approaches to reality, but also, to some extent, as means of creating awareness among citizens and of fostering public participation. SYNENERGENE activities were conducted in various European regions (mainly Central, Southern, South-Eastern and Western Europe, but with significant activities also in Northern and North-Eastern Europe). The other activities have mainly taken place in US. The project took into account EU, national, local, and international levels and made use of a wide variety of event “formats”, including major outreach events. The work of the project has been relevant to a variety of European, national, local and international activities concerning the governance of and societal discourse on RRI and SynBio.

1.2 Summary description of project context and objectives

SYNENERGENE had the following six main objectives:

- (1) to make existing practices of RRI in SynBio socially more robust,
- (2) to mobilise new stakeholders to participate in discourse on SynBio,
- (3) to involve the general public and specific “publics” and improve the quality of public participation by a wide variety of means,
- (4) to analyse and to make available the results of all public dialogue and stakeholder-oriented activities to policy makers, other stakeholders and the public,

- (5) to promote mutual learning processes between a wide variety of established and new stakeholders in discourse on SynBio, stimulating reflection and activities on novel and innovative avenues to an inclusive governance framework in accordance with a European concept of RRI and of high international visibility, and
- (6) to help develop sustainable agendas for RRI in SynBio which systematically take into account the views of citizens involved in public communication activities.

In order to reach these goals, the SYNENERGENE consortium has first formed – together with the existing networks of the consortium partners, including seven members of ECSITE, the European network of science centres and museums, and representatives of the iGEM (International Genetically Engineered Machine competition) community – a major SynBio in Society network. The consortium itself encompassed a wide range of stakeholders and expertise (e.g. SynBio researchers, companies, civil society organisations, technology assessment experts, ethicists, and artists). Furthermore, the organisational structure was tailored to the specific needs of an MMLAP, combining vertical and horizontal elements, facilitating a process of continuous mutual learning, and allowing for a high degree of flexibility when it comes to requests of external partners for cooperation and with regard to opportunities to support relevant activities of others.

The project entailed four phases:

- In phase 1 (until mid of 2014), a high-profile activity on RRI in SynBio was conceptualised and the ground prepared for it, mainly by means of consortium-internal interaction, including ECSITE members, representatives of the iGEM community and others.
- In phase 2 (until February 2016), the SYNENERGENE network established itself as a temporary institution of transnational mutual learning highly visible among relevant stakeholders and increasingly active in public activities. Many activities were conducted in cooperation with external partners.
- In the third phase (until October 2016), collective experimentation in RRI and agenda-setting for RRI in SynBio was continued, again with many new external partners.
- In its final phase (until June 2017), SYNENERGENE further contributed to societal discourse on SynBio, including activities outside Europe, and the project results were be widely disseminated and made use of, also by external partners.

1.3 Description of the main S&T results/foregrounds

SYNENERGENE has carried out more than 120 single events as planned, and additionally a plenitude of other activities, including many conducted at the initiative of, and in cooperation with external partners. The latter was made possible by its flexible approach, and the very large number of these so-called “extra” activities is testament to the high profile the SYNENERGENE project has gained among relevant stakeholders in Europe and beyond.

While a wide variety of public participation and outreach activities took place in SYNENERGENE, often at a local level, whose results were subsequently fed into other activities of the project, the other important focus of SYNENERGENE was on stakeholder activities and interaction. Among the specifically addressed stakeholder and other groups were artists, civil society organisations (including faith-based groups and organisations), the do-it-yourself biology (DIYBio) and biohacking community, education professionals, industry representatives, natural scientists and engineers, policy makers, science journalists, and young people (e.g. students from a wide variety of fields, including the iGEM community). In line with its work plan, SYNENERGENE allowed many

of these stakeholder groups to develop their own strategies, but at the same time organised or supported multi-stakeholder interaction, also in public settings.

One key feature of the SYNENERGENE project has been the fostering and use of art-science interfaces in which these were mainly conceptualised as means of an exchange involving two different approaches to reality, but also, to some extent, as means of creating awareness among citizens and of fostering public participation. Some of these activities, such as the second BIO·FICTION Science Art Film Festival which took place 23 - 25 October 2014, have been exceptionally successful. Another main aim of the project, namely the intensive and broad cooperation with the international iGEM community has likewise been very successfully realised. In the course of the project, these activities targeted at the next generations of SynBio researchers, have continuously grown, and the project as well as the European understanding of RRI and the related US concepts are now strongly present in the iGEM community. Moreover, members of the SYNENERGENE network will continue to cooperate with the iGEM community in the future. The same is true for other stakeholder groups such as civil society organisations, science journalists and the DIYBio community (aka biohackers). All these activities had a strong international dimension and thus complemented other SYNENERGENE activities which were specifically designed for this purpose, such as diverse transatlantic exchanges which included policy actors and a wide variety of stakeholders.

SYNENERGENE activities, which have been coordinated by the Karlsruhe Institute of Technology (KIT) under the lead of its Institute for Technology Assessment and System Analysis (KIT-ITAS), were conducted in various European regions (mainly Central, Southern, South-Eastern and Western Europe, but with significant activities also in Northern and North-Eastern Europe). The other activities have mainly taken place in North America but some activities have also been conducted in other continents. The project took into account EU, national, local and international levels and made use of a wide variety of event “formats”, including major outreach events. The work of the project has been relevant to a variety of European, national, local and international activities concerning the governance of, and societal discourse on RRI and SynBio and a wide variety of materials is available to the public (for example at: <https://www.synenergene.eu/> and <http://www.fi.uu.nl/synenergene/>).

In the various work packages which roughly corresponded with activity platforms, a wide range of activity types were conducted on a variety of tasks. At the same time a large number of events and other activities took place as joint endeavours of the different SYNENERGENE platforms. In the following, we present a selection of events and other activities conducted in the project.

One major task was a real time technology assessment of potential SynBio applications, led by the Rathenau Institute. For this purpose, five independent processes of real-time technology assessment & scenario development have been organised and carried out by different SYNENERGENE consortium partners. Each of these processes included iGEM teams and resulted in different scenarios which afterwards have been discussed at various events. Selected iGEM teams reflected on the societal implications of their projects as part of the Human Practices component of iGEM, by creating future scenarios based on their project work. Their work was supported by assigned SYNENERGENE partners in the form of a grant of 5000 Euros and intellectual support through the process of real-time technology assessment. These activities took place continuously from 2014 to 2016, and the cooperation with iGEM started even earlier and continued also in 2017, even after the end of the SYNENERGENE’s running time. Topics analysed and discussed together with the iGEM teams included but were not limited to the potential contribution of SynBio to innovation in the fields of antibiotics and renewable energy and

for a future bioeconomy. The cooperation with iGEM teams also took place on national levels between SYNENERGENE consortium members and iGEM teams from such countries as France, Germany, the Netherlands, and Slovenia. SYNENERGENE was also as sponsor and present with various means at the iGEM Jamborees taking place during the project's running time.

The "SYNENERGENE Forum", a major event, took place in Amsterdam in June 2016. The organisation of the SYNENERGENE Forum was led by partner Rathenau Institute, with the support by all SYNENERGENE partners, including, in an important role (host for the majority of activities, including a major conference on RRI in SynBio), ECSITE member NEMO. SYNENERGENE also collaborated with external partners, in particular Mediamatic (Amsterdam) where a BIO·FICTION film night with discussions took place.

SYNENERGENE also analysed the challenges of adaptive biosafety assessment in an international mutual learning process. The work on this task was led by the partner LIS Consult. On June 23, 2016, prior to the large "SYNENERGENE Forum" event in Amsterdam, a workshop was held to which experts from research institutes, competent authorities, industry and CSOs were invited. Its main purpose was to identify 1) cases where risk assessments for genetically modified organisms fall short, 2) adaptive strategies maintaining a high level biosafety without unnecessarily hampering innovation, 3) specific needs (knowledge, instruments...), and 4) actors and processes. The workshop built upon the results of several previous expert meetings on biosafety assessment for synthetic biology (SCENIHR, CBD-AHTEG, and several meetings with US experts), which were summarized in a working document that was sent to invitees the week before the workshop. During the "SYNENERGENE Forum" on June 24, a workshop on adaptive biosafety assessment was organised by LIS Consult and Biofaction KG. About 45-50 people participated in this workshop. In a final step, the interview results were integrated with the workshop reports resulting in a strategy paper. The strategy paper was published at the SYNENERGENE website and presented at the exchange on experiences and perspectives from the SYNENERGENE project in Brussels, April 24th-25th 2017. The results of the strategy paper were also summarised in an article for the SYNENERGENE Newsletter (no 06).

SYNENERGENE partner Athena Institute of the Free University of Amsterdam developed the frame reflection lab (FRL), a tool for reflexive learning for SynBio professionals and stakeholders. The FRL prototype was developed in an iterative process. The videos representing archetypical visions of science and technology were tested with citizens and researchers as participants, both individually as well as in group workshop settings. These tests provided insights into the contribution of these videos to frame reflection. These insights led to a new playful workshop design employing video-stories and reflection exercises in a stepwise exploration of different SynBio frames. This design was then applied and tested with 60 iGEM students at the iGEM jamboree 2014 in Boston. We learned that the video-stories worked well to stimulate discussion. The reflection exercises really took the participants from first prejudice to more nuanced understandings of why a particular character viewed things in a certain way. The tool was then made transferrable: movies have been revised, a facilitator guide was produced, and the design of the reflection exercises and workshop 'tangibles' were optimised. The redesign was tested with professional stakeholders, general citizens and young high-school students. In October 2015, a first TransLearning session took place in Bristol by means of canvasses. The second TransLearning workshop in Amsterdam (June 2016) functioned as a teaser to get many SYNENERGENE partners listen to stories at the same time, and to take a step of translating

lessons learned about organizing SYNENERGENE events to the level of lessons on organizing PE events in RRI contexts in general.

Another innovative means of science communication and mutual learning developed in SYNENERGENE (by the partner Athena Institute of the Free University of Amsterdam) is the Theatrical Debate (TD). It is a one-evening event comprising of an introductory mini-lecture about SynBio, given at the beginning of a TD event, and several scenes to perform – with improvisation space for actors – with each a distinct goal, actor role-divisions and moderator tasks. Scenes comprise of sketches and debate with the participants. The sketches address different possibilities and dilemmas of SynBio and the debates are meant to deepen the reflection throughout the scene. Sketches and debate carefully build upon one another by means of improvisation and moderation of the facilitator. In spring 2015 we tested the TD prototype in various cities in the Netherlands in order to unravel in what way and to what extent the sketches support people in making meaning, i.e. the ability to articulate an own opinion on SynBio related possibilities and dilemmas during the discussions or afterwards. By prototype testing, we also aimed to gain insights on to what extent the TD prototype supports the creation of mutual understanding among TD participants, namely understanding of own and other perspectives on issues related to SynBio. Third part of our investigation focused on the degree to which TD participants experience the process as equal, respectful, engaging and accessible. These three steps were useful to estimate the potential of using the TD as a (first) step in more extensive SynBio deliberation processes. In addition to these experiences with the TD prototype, we organised TD performances in the context of two larger SYNENERGENE stakeholder and public events.

Together with seven members of ECSITE (the European network of science centres and museums, a SYNENERGENE partner), including one member from Brazil, SYNENERGENE carried out a process of mutual learning between science communicators and other project members, resulting in a plenitude of public science and participation events and the development of new tools for the public engagement with science and technology and RRI in SynBio in particular. SYNENERGENE partners and seven ECSITE Third Parties (science centres and museums) involved more than 2,500 participants in nine countries in Europe and beyond in mobilisation and mutual learning activities. Along with other activities, they organised more than 30 different events and activities. In total, the partners made use of, tested, and implemented more than ten various formats of public engagement activities. To name some of the examples of these formats: participative theatre, the theatrical performance, student science parliament, informal dialogue activities - workshop with public opinion survey, science cafe, art & science festival, on-line forum, interactive talk, laboratory activities, conference sessions and panels, installations, and artistic performances. The topics covered in the cooperation with ECSITE members included but were not limited to the antibiotic crisis, synthetic proteins, lab grown blood, and the production of synthetic vanillin.

A major thematic strand of SYNENERGENE was named “Arguments, Values, and Images – Augmenting the Academic and Public Debate”. Here, SYNENERGENE partners, in particular from the universities of Freiburg and Paris, promoted out-of-the-box thinking concerning major philosophical and societal issues of SynBio, also in interaction with the public. After the workshop “Worldviews and Values in Synthetic Biology”, at Université Paris 1 Panthéon-Sorbonne, on 6-7 June 2014, a second workshop, on “Redesigning Synthetic Biology - Towards a Constructive Critique of a Technoscience”, took place at Universität Freiburg, on 2-3 July 2015. The workshop partly took place in parallel with an event of the Theater Freiburg (the theatre of the city of Freiburg/Germany, a SYNENERGENE partner) which further enhanced this event. In order to

prepare questions and discussion, participants of the Paris and Freiburg workshops were asked to fill in a questionnaire in advance of the workshop days.

A major event, named “‘Life’ on stage: Synthetic life at the theatre”, took place at the Theater Freiburg, Germany, 3-4 July 2015, organised by SYNENERGENE partner Theater Freiburg in close cooperation with other SYN-ENERGENE partners. During these two days, student groups presented performances developed for this event, professional theatre performances were shown, and participants were introduced to and discussed societal and ethical aspects of synthetic biology with experts. On Friday, July 3, visitors were introduced to SynBio and its ethical aspects. By means of a world café format, visitors were further informed about specific issues of the debate on SynBio. World café experts included participants of the Freiburg workshop “Redesigning Synthetic Biology” that took place the previous two days. After the world café, a panel discussion took place on the relation of SynBio and art. On Saturday, July 4, consortium-internal and external experts discussed SynBio at four panels. In the evening, the professional play „NATURZWEI“ was shown in the „Kleines Haus“.

Another public dialogue event took place in Karlsruhe, Germany, on September 16th, 2015. This event was one of a total of 14 “Stadtgespräche” (“Talks of the Town”) that were set in the framework of the 300th anniversary of the city of Karlsruhe at the festival pavilion in the castle gardens. The audience (roughly 150 participants) was invited to ask questions, but also to take a seat next to the three panelists Joachim Boldt (Freiburg), Christopher Coenen, and Thermo Fisher Scientific’s / GeneArt’s Michael Liss (all from the SYNENERGENE consortium). A short introductory video, which is also available online, started the discussion. It features interviews with citizens in Karlsruhe who were asked one of the following questions: “What is synthetic biology?”, “Is it good or bad?”, and “Should politics regulate the technology?”. The discussion was hosted by Caroline Y. Robertson-von Trotha, director of the Centre for Cultural and General Studies (ZAK) of the Karlsruhe Institute of Technology (KIT). KIT-ZAK also collected short feedback from the audience, creating a sample of 95 persons.

As the EC officials in charge of the project already agreed to in 2013, a number of activities on the important topic of do-it-yourself (DIY) biology have been conducted within SYNENERGENE. The main aims of these activities were to bring European RRI discourse more to the attention of the European and global DIYBio community and to allow for input of the DIYBio community into the SYNENERGENE project activities and European RRI on SynBio at large. Building on the results of a Bio-Commons workshop in Helsinki, which took place as a SYNENERGENE extra event and as part of the Pixelache Festival from 6-8th of June 2014, a number of further DIYBio workshops working on the Bio-Commons topic and other topics took place. This included, for example, participation in the Commons Camp in rural Italy, co-organised by the Rural Hub and Qui Share, during which bio-value and bio-capital in the age of ubiquitous biotechnologies and of smart communities were discussed. Over the course of 6 days, DIY biologists and others interested in the commons of the living took part in the discussions.

A call for applications for an artist-in-residency programme of SYNENERGENE partner University of Southern Denmark (SDU) received 48 applications from which eight were shortlisted, two interviewed and eventually one selected for the six-week residency in Denmark. The jury consisted of scientist Steen Rasmussen (SDU), artist Laura Beloff and curator Jens Hauser. The interdisciplinary artist Orkan Telhan, who is also an assistant professor of Fine Arts at University of Pennsylvania, was chosen as the artist in residency for a six week programme at the Center for Fundamental Living Technology (FLinT), University of Southern Denmark, in 2015. Preliminary outcomes of the work were presented first through a remote presentation given for the Society for

Literature, Science, and the Arts (SLSA) Conference on Neolife, Perth, Western Australia, and later at the IT University of Copenhagen, Copenhagen, Denmark. The work “Bananaworks” developed during the residency has been exhibited at Wetware: Art | Agency | Animation; an international art exhibition at the Beall Center for Art + Technology curated by Jens Hauser and David Familian. The project has also been invited by the prestigious 3rd Istanbul Design Biennial, which took place in Istanbul, Turkey, October-December 2016. In 2017, Telhan received an Honorable Mention at the Prix Ars Electronica Festival, Linz/Austria, and he was selected as a 2016 finalist in the Social Impact category of SXSW Eco's Startup Showcase.

The Finnish Bioart Society (FBAS), another SYNENERGENE consortium member, organised a series of “Making Life” art-science workshop series, supported by other SYNENERGENE partners. They took place in the years 2013-2015. One example was “Making_Life III” which was held at Biofilia – Base for Biological Arts - Aalto University from 17th to 23rd of May 2015. Four thematic groups which had formed during Making_Life II worked towards finishing an artwork for the Making_Life exhibition at the Lasipalatsi gallery in Helsinki. The Making_Life exhibition opened in Friday 22nd of May and lasted until 31st of May. About 60 visitors attended the exhibition opening and about 300 visitors the exhibition. A symposium about art and synthetic biology was held on 23rd of May as finalisation of the project, with about 30 participants. In the seminar, Making_Life participants gave an introduction to synthetic biology and why and how they are interested in engaging with it. They discussed key technologies, promises, the hype which surrounds SynBio and the resulting cultural perception. The MAKING_LIFE platform, originally a Wordpress site, was used as a template to transfer the content into the new website of the Bioartsociety during 2017. It is now available under http://bioartsociety.fi/making_life/.

On June 28th, 2015, the “Supernova – Science Theater: SynBio-Hack-Meck” event took place in Karlsruhe, staged by KIT-ZAK in cooperation with Badisches Staatstheater Karlsruhe and within the context of the EFFEKTE festival. At this science-on-stage event, Christopher Coenen, as the SYNENERGENE coordinator, and DIY biologist / bio-hacker Rüdiger Trojok were on stage with an actor of the Badisches Staatstheater Karlsruhe in the EFFEKTE dome on the Karlsruhe castle square. The event combined lecture with theatrical performance. In the latter, the two researchers were actively involved. The public was successfully inspired to take part in both, the performance and the subsequent discussion. Around 25 citizens participated in this event. (The number of participants was restricted due to the character of the location which allowed for an immersive atmosphere for the performance.)

Biofaction KG organized the second BIO·FICTION Science Art Film Festival October 23-25, 2014 with the support of the Museum of Natural History in Vienna, Austria. BIO·FICTION discussed, documented, and explored the emerging field of SynBio and initiated a public discourse on it. In order to facilitate a creative conversation, the event featured a large variety of content: 32 presentations, panel discussions, five do-it-yourself biology demos, three art performances, and film screenings. The trans-disciplinary symposium was set in Vienna's Museum of Natural History and explored, amongst other topics, bioengineering, bioart, ethics, responsible research and innovation, intellectual property, entrepreneurship as well as do-it-yourself biology. The 40 participants (speakers, panellists, artists, workshop instructors etc.) came from a wealth of backgrounds, including science and engineering, the social sciences, cultural studies, DIY biology, the military, film making, art and design. In accordance with its objective, all BIO·FICTION events were open to the public and free of charge. The audience included not only locals, but also visitors who travelled from abroad. Around 150 visitors registered for the festival, which does not include casual unregistered guests or footfall from museum visitors. Like its first edition in 2011, the second BIO·FICTION festival was a highly rewarding event which connected diverse people and

facilitated new avenues of discussion. One cornerstone of the festival was the international short film competition, which introduced documentaries, animation, and fiction shorts that explored the thematic. The call for submissions was answered by 100 submissions from 17 countries and four continents. 60 entries were shortlisted and reviewed by an international jury of nine. The screenings were held at the nearby Bellaria film theatre, one of Vienna's oldest film theatres, and the award ceremony took place during the final BIO·FICTION gala, the evening of October 25th. In the framework of the SYNENERGENE project, BIO·FICTION has been sent to 32 locations across the world, on all continents (Europe, Asia, Africa, Australia, North America, South America, Antarctica). All film screenings were accompanied by a follow-up panel discussion with the audience to reflect and discuss on the ideas, narratives, and concepts shown in the films. Furthermore, SYNENERGENE partner TU Delft conducted in-depth analyses of various activities at the intersections of science and art, working also with BIO·FICTION films and participating in a number of events organised by external institutions, thereby bringing SYNENERGENE and European concepts of RRI in SynBio to the attention of diverse audiences in particular in the Netherlands.

On December 9th, 2016, the University of Ljubljana in collaboration with Biofaction KG organised the multimedia public event "Synthetic biology: bioreality and biofiction" that took place at the University of Ljubljana. In the first part of the event, which was dedicated to "bioreality", the synthetic biologists and social scientists presented various aspects, implications and challenges of synthetic biology, as well as the science-technology field itself. In the second part, which was dedicated to "biofiction", several art projects were presented in which artists, scientists, and engineers are collectively experimenting and creating on the edges of the thinkable by using technologies and biotechnological protocols. This was followed by the mini film-art event "BIO·FICTION@Ljubljana 2016" which presented award-winning short films. These films incorporate and interpret synthetic biology as well biotechnology in a broader sense, in a variety of ways, including the related prospects, dilemmas, and societal issues. The film screening was followed by a short panel discussion on the integration and importance of science and art in contemporary society. The event has successfully brought together experts from disciplinarily very diverse areas, who jointly discussed some of the current issues and challenges in the field of synthetic biology, biotechnology, applications, art, and societally desirable progress with the wider public. KIT-ZAK, in collaboration with Biofaction KG, organised a film screening on synthetic biology in the framework of the "Karlsruhe Science Film Days" which took place from June 29 to July 2, 2017.

In order to further contribute to mutual learning on prerequisites for RRI in SynBio, a series of stakeholder workshops took place. Following a first workshop organised by the Technical University of Darmstadt in Darmstadt, Germany, which focused on the European level, two workshops with a national and regional focus were conducted. The two events brought together stakeholders from the South and Central European regions and were organised by the University of Ljubljana and the University of Padua, respectively. The two events were combined, in order to increase opportunities for mutual, transnational and transregional learning. They took place under the common heading "Perspectives and Key Issues in Synthetic Biology: Opportunities, Risks and Policies" in the City Hotel in Ljubljana, Slovenia, 18-19 June 2015. The plenary interactive sessions on both days were facilitated with professional support by SYNENERGENE partner University of Bristol (Centre for Public Engagement). Participants of the event represented various relevant stakeholder groups from South and Central European regions, and included, amongst others, SynBio researchers, bioethicists, sociologists of science and technology, political decision makers, business representatives, and civil society organisations. Originally, the intention was to have around 25 participants, but this number ultimately reached around 40 participants from Italy,

Slovenia, Austria, Croatia, and Serbia as well as one expert from the EC and representatives of SYNENERGENE partners from Germany and the US.

The SynBio Policy Meter, an online platform created by University of Padua, aims to provide topical and reliable knowledge for the assessment of policy priorities and “hot-button issues” relevant for experts and stakeholders. It was developed with the help of an online Delphi survey. The Delphi technique structures group communication so that the process is effective in allowing a group of individuals, as a whole, to reach consensus on a complex problem. A Delphi requires a group of respondents to answer a series of questionnaires interspersed with controlled opinion feedback. 31 respondents participated in the first round of the Delphi (October-mid-November 2016), 28 in the second round (November-December 2016). Both questionnaires aimed to identify, assess, and evaluate stakeholders’ opinions, attitudes, and proposals on: (1) specific emerging synthetic biology applications; (2) the distribution and the management of costs and benefits of specific synthetic biology applications among different social actors and social realms; and (3) governance and regulatory tools. In general, respondents of the Delphi survey (encompassing scientists and researchers, CSO representatives, policy makers/policy advisors, business representatives and science communicators) strongly agreed (i.e., showing a high level of convergence) on the magnitude of the costs and benefits of several SynBio applications, as well as on some governance and regulatory tools that may be appropriate to govern them. A detailed description of the Delphi results is available at <http://cigasynenergene.wixsite.com/synbiometer>.

As the first of two transatlantic SYNENERGENE workshops on innovation policy issues, a workshop on “Creating Responsible Bioeconomies” took place in Brussels, 8-9 October 2015. It was hosted in cooperation with the Royal Flemish Academy of Belgium for Sciences and Arts in the Palace of the Academies. 27 European and US experts from the fields of policy making, industry and CSOs, including EC staff, attended the event. On April 24th – 25th, 2017, a workshop on “Mutual Learning in Synthetic Biology: Policy Implications of RRI” was held in Brussels, organised by KIT-ITAS and supported by SYNENERGENE partner Woodrow Wilson International Center for Scholars (WWICS) and other partners. At the event, which included views from the North America, lessons learned in the SYNENERGENE project were presented and their relevance to EC policies concerning responsible research and innovation (RRI), SynBio and the bioeconomy was discussed with EC officials, stakeholders, SYNENERGENE partners and other experts. Some policy-relevant findings from the workshop are: Risk research on SynBio is increasingly lagging behind innovation and several proposals were made to improve the handling of risks. There is a need for more RRI tools for scientists, business and NGOs. Biosecurity issues are still lacking the appropriate level for oversight in Europe. Open spaces should be created for deliberation of cultural and religious values (rather than opinions). Industry and civil society actors may share common values, but the discussion tends to keep focused on the different approaches to tackling grand challenges (technical versus social innovation). Governance for innovation and innovation in governance are required, and a move from risk governance to innovation governance was suggested. This move may require institutional change, in addition to new tools for regulators, as well as the development of open public-private partnerships into public-private-societal partnerships. When it comes to ways forward to RRI in SynBio, both holistic and focused approaches are needed. Contributions of insights from SYNENERGENE can be relevant to negotiations on the Convention on Biodiversity, the UN Technology Facilitation Mechanism and for other international activities.

On 22-23 September 2015, SYNENERGENE partner WWICS carried out two trading zones in Washington, DC, in cooperation with Eri Gentry of the Institute for the Future and others, that were conceptualised in a way that both topics would enrich each other: one meeting unveiled a set of

thought-provoking reflections around biodiversity, socially-driven innovation and the bioeconomy agenda; and the other meeting questioned IP models for synthetic biology and the bioeconomy, with a special focus on open-source biology and its potential to thrive in non-traditional and non-institutional settings, such as community bio labs, bio-incubators, and open-source start-ups. The trading zones were attended by more than 50 people who represented a broad spectrum of fields, including a number of people who provided expertise on biodiversity, IP, open-source biology, and the bioeconomy. Several of the participants work in research institutions, such as the NIH or Stanford University. Others work in start-up companies such as Poliwogg and Intrexon. In addition, many of the participants have been working in many government agencies such as the FDA and USAID. Furthermore, several individuals have had experience in venture capitalism for companies such as Draper Fisher Jurvetson.

As a case study on challenges raised by bio-research in non-institutional settings, partner WWICS has also conducted a study on the topic of genetically modified ornamental plants, in particular the plan to create, by means of SynBio, bioluminescent plants that glow in the dark and lawn grasses that require less mowing and are deeper green in colour. The study discussed these developments and plans with a view to the US Plant Protection Act.

The SYNENERGENE project also organised five Open Forums (Business, Civil Society, Media, Policy, Science) which ran during the entire running time of the project. They displayed a large degree of diversity from the start, and this diversity has even increased during the project's running time. While the Civil Society Forum (chaired by What Next Forum) and the Media Forum (chaired by EUSJA's Sascha Karberg) both had a very detailed, predefined agenda and a predetermined structure, the Business Forum (chaired by Thermo Fisher Scientific / Gene Art), the Policy Forum (chaired by Wolf-Michael Catenhusen) and the Science Forum (chaired by ETH Zurich's Sven Panke) and their activities were designed and determined in an iterative learning process and based on the input by the respective stakeholder groups. Moreover, the interests and the motivations of the respective groups to get involved were diverse, too. The Media Forum provided science journalists with the opportunity to discuss with colleagues and a variety of experts from the SYNENERGENE consortium and some external partners about science journalism and its role in the science and innovation system. Science journalists cannot be expected to play a role as stakeholders similar to, for example, CSOs or firms. The involvement of science journalists in SYNENERGENE could, as a general rule, only be sporadic and an unusual extra activity for them in their work lives. The involvement of CSOs in the Civil Society Forum has been relatively strong, since this OF was designed in a way that seamlessly integrated with other civil society stakeholder activities around SynBio. Getting involved in the SYNENERGENE activities was thus a "natural" activity for these stakeholders and they spent quite significant amounts of time and resources for it, due to a high degree of intrinsic motivation. In the cases of the Business Forum and the Science Forum, the situation has been in some regards similar, but RRI in SynBio (and, more generally, 'science in society') activities are not part of the "core business" of these stakeholders. Sometimes they might even prefer, for various reasons, not to get involved in such activities, so it was difficult to plan in advance and to predict the outcomes of the SYNENERGENE Business Forum and Science Forum activities. As regards the Policy Forum, the interest of policy makers in science and society and RRI in SynBio issues exists, but, again, some policy and other public decision makers can be hesitant to get involved in these issues, and the schedule of policy makers tends to be very tight. Nevertheless, all Open Forums organised, co-organised or contributed to major multi-stakeholder activities, in addition to events which were dedicated to discussions on RRI within their respective stakeholder group (such as several meetings of CSOs during the course of the project and a SYNENERGENE Business Forum meeting organised in Regensburg/Germany by partner Thermo Fisher Scientific / GeneArt). These included but were not limited to the following: (1) the

workshop “Civil society in action for the governance of emerging technologies (such as nanotechnologies and synthetic biology)” in Tunis, 26th of March 2015, an event of the SYN-ENERGENE Civil Society Forum. This event was organised by SYNENERGENE partners etcGroup and What Next Forum in association with external partners at the World Social Forum/ World Forum on Science and Democracy. (2) the workshop “Governing Biotech 2.0: how synthetic biology will impact rights, livelihoods and life” which took place in Geneva, 9th of December 2015. It was again organised by partner etcGroup in close collaboration with SYNENERGENE partner What Next Forum (chair of the SYNENERGENE Civil Society Forum) and the International Union of Food, Agricultural, Hotel, Restaurant, Catering, Tobacco and Allied Workers’ Association (IUF) in Geneva, at the headquarters of the International Labor Association (ILO). (3) a European workshop on “Exploring the future governance of SynBio and new genetic engineering techniques” which took place in Brussels on the 27th of June 2016 at the offices of BEUC (European consumer Organisation) and was also attended by EC officials and experts. (4) a workshop on criteria for synthetic biology reporting, co-organised by partner EUSJA (chair of the SYNENERGENE Media Forum) and SYNENERGENE partner WWICS, together with external partners (in particular the Knight Foundation), in Cambridge/MA in November 2016. Science journalists, academics, and representatives of various stakeholder groups discussed a prepared set of criteria that has been devised by the German Mediendoktor Team, and afterwards the journalists were asked to develop a set of their own “Mediendoktor-Synthetic biology” criteria. Journalists who were invited represented international, influential organisations such as The World Federation of Science Journalists, the European Union of Science Journalists, Columbia News Review, and the MIT Knight Science Journal Fellowship. There was also an opportunity to discuss the criteria with an international audience of science journalists at the World Conference of Science Journalists in San Francisco in June 2017.

The University of Bristol used a participatory theatre production for the purpose of public engagement with and information on SynBio. ‘Invincible’, the participatory theatre production, was produced by the external partner Kilter in partnership with staff from the SYNENERGENE partner University of Bristol, including synthetic biologists at this institution, thereby combining SynBio researchers’ and public engagement. Set in a modern family house in a fictional future, the performance immersed the audience in the very possible personal and family dilemmas that might arise as a result of developments in SynBio. The activities took place in Bristol in February and March 2017. The main aims concerning young people and other members of the general public were (1) to raise awareness of (the existence of) synthetic biology, possibilities, and dilemmas that may arise by the raise of SynBio in our society, and (2) to support young people and other members of the public in developing and expressing their own perspective on synthetic biology and more broadly the role of science and technology in our lives. The main aims concerning SynBio researchers were (1) to gain experience working with a theatrical production company to express research ideas, (2) to develop confidence in engaging young people and the public and responding to questions through a Q&A format, and (3) to support further reflection on the future applications of synthetic biology and to listen to young people’s and other public views on their research.

Gene Rowe Evaluations was the SYNENERGENE partner in charge of evaluating public (and, to some degree, stakeholder) engagement processes conducted within the project, in order to ensure good process and relevant impact (on mutual learning, communication, information exchange, etc.). In addition, this partner frequently gave feedback and advice to the SYNENERGENE Steering Committee and to individual SYNENERGENE partners. This included but was not limited to advice on the Delphi survey and the evaluation of a Pavilion of Knowledge event, 31st of March 2016, of ECSITE member Ciência Viva.

Another SYNENERGENE consortium member, the Institute of Technology Assessment (ITA) of the Austrian Academy of Sciences analysed a wide variety of public events organised in SYNENERGENE. ITA identified four design and process principles to make public dialogue events more interactive and engaging, which could be summarised as following: (1) Avoid meta-debates; make the discussion concrete and relevant: In order to elicit engagement, SynBio needs to be made easier to handle especially for lay people. The moderator or facilitator has an important role in actively encouraging participants to refer to SynBio, to provide examples or to invite a researcher to talk about their laboratory practices. (2) Make use of the variety of framings and encourage frame reflection: The agenda-setting is a crucial element in the organization of public engagement events. By confronting participants actively with different framings of SynBio, a reflection of the participants on their own positions and underlying views can be encouraged. (3) Transform informational input into two-way communication: To avoid the risk of a top-down enforced debate and to encourage “mutual learning”, organizers could re-think the provision of informational input. (4) Avoid overly academic debates, encourage creativity and emotions: Public dialogue events could benefit from clear signals that everybody is invited to join the discussion and that emotions and non-academic arguments are welcomed as well. Formats such as theatre performances or films have the potential to stimulate imagination and innovative thinking that might lead to more unconventional but nevertheless important perspectives and concerns on SynBio.

Last but not least, a wide range of online activities took place in SYNENERGENE, with ZebraLog as the leading partner, other partners (such as Utrecht University, the University of Padua, SDU, ECSITE, KIT, LisConsult, UP1, and etcGroup) making major contributions. To name but a few of these activities: The project platform www.synenergene.eu developed by SYNENERGENE partner ZebraLog, has developed into a major ‘online hub’ for communication about the project’s activities and about SynBio and RRI news more generally. SYNENERGENE’s newsletters, sent out by partner LisConsult, continuously reported on SYNENERGENE activities and topics relevant to RRI in SynBio. Online discussions facilitated by Science Museum NEMO took place on the Kennislink platform. The University of Padua developed a web tool (Synthetic Biology Monitor - SBM) that provides a one-stop access to various types of documents on ethical, legal and societal aspects of synthetic biology (academic articles, reports, policy documents) from a variety of sources. The tool is available online at www.ciga.unipd.it/sbm. Regarding civil society online communication, etcGroup and What Next Forum created a closed e-mail list and a separate website www.synbiowatch.org. Two webinars were conducted in the second half of 2016, one on “Synthetic Biology and Climate Smart Agriculture”, and one on “Synthetic Biology Food and Ingredients”. In December 2016, the Captain Hook Awards for Biopiracy were broadcasted live from Cancun, Mexico. The goal of the iGEMer’s Guide to the Future, which is available online, is to help students participating in the iGEM competition with the human practices part of their work, or in other words to do responsible research and innovation. The Guide helps doing responsible research and innovation by offering a number of activities that allow analysing the context of their innovation, organising interactions with stakeholders, and imagining the future of their innovation (scenario building). The Synthetic Biology Learning Platform, developed by Utrecht University, gives access to a wide variety of aspects of SynBio and RRI in a structured manner (www.fi.uu.nl/synenergene/).

1.4 Potential impact

After having carried out its more than 120 planned single events and a plenitude of other activities, including many conducted at the initiative of and in cooperation with external partners, SYNENERGENE hopes to have made major contributions to the raising of awareness of SynBio among a wide variety of stakeholder groups, in specific publics, and in the general public. Designed as an iterative mutual learning process, SYNENERGENE developed during its running time into a quantitatively and qualitatively unprecedented as well as procedurally innovative activity

of public learning about and engagement with SynBio and a truly transnational mutual learning process.

One obvious impact of the project is its wide coverage in the media. To give but a few examples: (1) SYNENERGENE partner WWICS has conducted major online and other media outreach activities, in particular in the US. (2) The artist-in-residency programme at the Center for Fundamental Living Technology (partner University of Southern Denmark) was covered in the newspaper “Der Tagesspiegel”, Berlin, Germany. (3) The session on SynBio at the German Protestant Kirchentag and the various public events in Karlsruhe/Germany were widely covered in important regional media and partly in national media. (4) The BIO·FICTION Film Festival in Vienna in 2014 was widely covered still in 2015, including in academic publications. (5) The work of SYNENERGENE partner University of Ljubljana has been widely covered in Slovenian media (such as the newspaper “Delo” and in radio). (6) SYNENERGENE partner SDU (Denmark) has published a number of op-eds, a book, organised workshops, as well as a manifesto on the technological impacts of living and intelligent technologies and given lectures to the general public. (7) An article by Joanna Roberts (“When science meets art”) for the European Commission's Horizon Magazine covers the work in SYNENERGENE to create public conversations through artistic and cultural events. The article was published in November 2015 on the Horizon website. (8) The collaboration of SYNENERGENE (and Harald König from KIT-ITAS, in particular) with the iGEM 2014 team of Valencia Biocampus resulted in a publication in the important academic journal “EMBO Reports” in August 2015 (<http://embor.embopress.org/content/16/9/1055>). (9) In 2015, Toni Pustovrh of SYNENERGENE partner University of Ljubljana conducted a roundtable with prominent Slovenian experts on the topic of “Interdisciplinary views on biotechnology, art and society” that was held at the BIO·FICTION@Ljubljana event for the public in Stara mestna elektrarna. The event was covered in the cultural show Kulturnice on the national radio.

Furthermore, printed SYNENERGENE project flyers were used continually in order to provide information on the project and to specifically promote certain SYNENERGENE activities. For this purpose, the flyer was adapted according to the respective events, based on a common basic layout and appearance. At the iGEM Jamboree 2015, for example, SYNENERGENE advertised its RRI activities not only in the event’s brochure but also with customised flyers that were handed out to the 3,000 participants. Given the fact that a wide communication and dissemination of project results and other thematically relevant information was a key element of the SYNENERGENE MMLAP, a large number of communication and dissemination activities have been carried out by the project that had not been planned in advance of the project. To give but one example of such an activity: The SYNENERGENE Policy Forum (chaired by Wolf-Michael Catenhusen) and the SYNENERGENE coordination team at KIT-ITAS co-organised a session on SynBio at the Kirchentag in June 2015, a biannual large-scale event of the Protestant Church in Germany. Several SYNENERGENE partners played important roles in this session. The three hours session took place in Stuttgart’s Porsche Arena on the 4th of June, featured talks and discussions by high-level representatives of academia, civil society organisations and the policy sphere, and it was attended by about 1,200 participants who could address questions and send comments to the SYNENERGENE team (online or on paper). To our knowledge, the session was the largest public discussion on SynBio in Germany so far. BIO·FICTION films were screened and introduced by SYNENERGENE coordinator Christopher Coenen (KIT-ITAS). Theresia Bauer, Baden-Württemberg’s Minister of Science, Research, and Art who was one of the panellists, was personally informed about the SYNENERGENE project in advance of the session. The analysis and documentation of this session, including comments of the audience during and after the session, were carried out by KIT-ITAS (Steffen Albrecht) and shared with the Kirchentag organisers.

SYNERGENE partner UP1 has conducted the FESTIVAL VIVANT in September 2016 in which various stakeholders from the area of agriculture-industrial uses of SynBio were involved, including four iGEM teams. The SYNERGENE partner plans to continue activities inspired by SYNERGENE and building on its results, with a focus on a variety of bio-economy topics and in cooperation with the BioRESP Forum.

Another major dissemination activity, this time targeting academics as well as other stakeholder groups, took place at the 8th annual meeting of the Society for the Study of New and Emerging Technologies (S.NET) in Bergen, Norway, 12-14 October 2016, which was organised by SYNERGENE partner University of Bergen. The conference with the title 'The Co-Production of Emerging Bodies, Politics and Technologies' invited researchers, stakeholders and others to reflect on emerging technologies and their politics. The S.NET meeting was also used to continue the work with the DIYBio/biohacking community (which was also continued in cooperation with national projects in EU Member States in other contexts). A series of sessions organised by SYNERGENE at the S.NET meeting put synthetic biology and RRI in the focus. In the organisation of this session, the SYNERGENE project took the lead, but the EU projects NERRI, PROSO and RRI Tools as well as national projects from EU Member States were also strongly involved. Since then, SYNERGENE results have been systematically fed into research in PROSO, and there have been various further exchanges between SYNERGENE and the other two projects. A publication focusing on the session is forthcoming (as a chapter in a volume of the S.NET book series). Moreover, BIO-FICTION was present in Bergen with an "on tour" event.

Currently (second half of 2017), the SYNERGENE consortium is in the process of establishing routines for continuing activities, also with external partners, as 'the SYNERGENE network'. It will also continue to feed project results into EU level, national, international, regional, and local research, policy and societal activities, including other EU or national research and dialogue projects. As regards all these levels, the in-depth analysis of the SYNERGENE activities is expected to create a robust basis for future activities concerning the discourse on RRI and SynBio as well as concerning RRI activities in related or similar fields of research and technology development, including future activities on the EU level. Many SYNERGENE partners have also already made plans to continue some of the work started in SYNERGENE or to develop new activities inspired by the SYNERGENE experience.

The online resources created by SYNERGENE as well as the project's network will continue to be useful for RRI activities in SynBio and related or similar fields, including activities targeted at or conducted by key stakeholder groups of SYNERGENE such as the iGEM community, science journalists, SynBio companies, facilitators of public engagement in science and technology, and a wide range of civil society organisations. The SYNERGENE website will be archived so as to allow for full access to all relevant project results and for contacting the SYNERGENE network members. We also expect that future activities at the intersections of art and science will be able to take advantage from networks created in SYNERGENE and be inspired by their activities.

Furthermore, we expect the work in SYNERGENE to be relevant to various academic communities, such as the community of researchers working in the field of science and technology studies. Making use of the already achieved visibility of the project in such communities and profiting from targeted outreach activities in the remaining time of the project, SYNERGENE partners aim to make a wide variety of impacts on academic discourse on RRI and SynBio. This will include the continuation of strongly interdisciplinary cooperation between SynBio researchers and experts from the social sciences and humanities.

Last but not least, the SYNENERGENE project results, including the created network, will continue to be useful for or directly interact with other EU and national projects (including but not limited to such European projects as PRISMA and PROSO). The SYNENERGENE network will thereby continue to help make RRI in SynBio more socially robust and further develop RRI in general.

1.5 Address of the project public website as well as relevant contact details

www.synenergene.eu

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