Towards a European Strategy
for Synthetic Biology

30 July 2008

Documentation of TESSY Stakeholder Workshop

Brussels, 10 June 2008

Opportunities for Stakeholders

(TESSY Deliverable D3.2)

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Content

1 Introduction

The TESSY Stakeholder Meeting was organised as a platform for knowledge transfer on Synthetic Biology (SB). Additionally, it was the event to launch and discuss the TESSY roadmap on Synthetic Biology for Europe. The agenda combined these different tasks by providing general information from the perspective of science, industry, policy and the public, and disseminating the TESSY roadmap. Additionally, policy approaches and future needs for Synthetic Biology were discussed in a panel discussion.

Table 1: Agenda of the Meeting

10:00 - 10:10	**Welcome & Introduction** *Sibylle Gaisser, Thomas Reiss, Fraunhofer Institute, Karlsruhe, DE*
10:10 - 10:50	**Challenges and Perspectives in Synthetic Biology Research** *Vitor Martins Dos Santos, Helmholtz Centre, Braunschweig, DE*
10:50 - 11:25	**Industrial Synthetic Biology – a glimpse on opportunities, challenges and responsibilities of an emergent industry** *Peer Stähler, febit, Heidelberg, DE*
11:25 - 12:00	**Synthetic Biology: responding to the social and ethical challenges** *Paul Martin, University of Nottingham, UK*
12:00 - 12:15	**Synthetic Biology in the EC** *Ioannis Economidis, European Commission, Brussels, BE*
12:15 - 13:15	**Lunch**
13:15 - 13:50	**Roadmap for Synthetic Biology in Europe** *Sibylle Gaisser, Fraunhofer Institute, Karlsruhe, DE*
13:50 - 14:15	**Policy approaches to furthering Synthetic Biology** *Thomas Reiss, Fraunhofer Institute, Karlsruhe, DE*
14:15 - 15:45	**Panel discussion on "Boosting Synthetic Biology in Europe – what is needed?"** The Panel will cover topics such as research funding, interdisciplinary training and academia-industry relationship. Moderator: *Astrid Lunkes (European Science Foundation, FR)* Panelists: *Matteo Bonifacio (Bureau of European Policy Advisers, BE)* *Amanda Collis (Biotechnology and Biological Sciences Research Council, UK)* *Leonard Katz (Synthetic Biology Engineering Research Center, Berkley, US)* *Martin Reddington (Human Frontier Science Program Organisation, FR)* *Luis Serrano (Centre for Genomic Regulation, ES)* *Daniel Vonder Mühll (SystemsX.ch, CH)*
15:45 - 16:00	**Conclusions and next steps** *Sibylle Gaisser, Fraunhofer Institute, Karlsruhe, DE*

2 Participants

54 participants from 14 countries with background in science, funding, politics and industry participated in the stakeholder event. Contact addresses of all participants are listed in the annex.

3 Key note speeches

The complete presentations can be downloaded from http://www.tessy-europe.eu/news.html

3.1 Challenges and Perspectives in Synthetic Biology Research

The research perspective of Synthetic Biology was covered by Vítor Martins dos Santos. He graduated in Bioprocess Engineering in 1992 at the College of Biotechnology, Oporto, Portugal, and earned a doctorate on Environmental Bioprocess Engineering at the Wageningen University, The Netherlands. He did a post-doc at the Dept. of Molecular Biology of the Spanish Scientific Research Council (CSIC) in Granada, Spain and moved subsequently to the Division of Microbiology of the National Centre for Biotechnology Research (GBF) (now Helmholtz Centre for Infection Research, HZI) in Braunschweig, Germany. He heads the Synthetic and Systems Biology Research Group at the HZI, where he runs several national and transnational Systems and Synthetic Biology projects focused on the understanding and exploitation of microbial behaviour for industrially and medically relevant applications. The presentation illustrated the core of Synthetic Biology with its two tasks

a) the design and fabrication of biological components and systems that do not already exist in the natural world

b) the re-design and fabrication of existing biological systems.

Vítor Martins dos Santos illustrated highlights of Synthetic Biology (SB) research such as the production of ideal biocatalysts from scratch, the re-factoring of bacteriophage T7 and the design and construction of genetic bistable toggle switch. Another success story of SB is the production of novel antibiotics from re-engineered polyketides. These examples showed that the approach of SB offers a broad range of opportunities in

1) Industrial Biotechnology: Re-programming cells for biocatalysis (fine chemicals, pharmaceutical compounds, hydrogen, biofuels, etc).

2) Environmental Biotechnology: Environmental applications, Re-programming regulation, engineering microbial communities, biodegradation, etc.

3) Medical Biotechnology: Re-programming stem cells, smart delivery of chemicals/antimicrobials, cancer therapy, etc.

4) Plant Biotechnology: plant cell re-programming, antibiotic production

5) Technical developments and milestones: Orthogonal ribosomes, driving evolutionary trajectories, reprogramming sensors, counting microbes, etc

The bases for a Synthetic Biology community are/will be established by

- recruiting the required competences from (not so) neighbouring disciplines;
- exploiting synergies (competences, expertise, complementarity...);
- fostering transnational/transcontinental communication & cooperation;
- promoting education at various stages (school, undergraduate, ..);
- embedding early developments into a meaningful societal / economical context.

The promises of Synthetic Biology will be realized if the following steps will be accomplished in the next years:

- invent, construct and test basic parts (functions) of complex (semi-)synthetic systems with well controllable, preferably monofunctional, programmable and robust behaviour;
- invent ways to efficiently integrate parts into complex synthetic systems that will to some extent alter cell biology and provide a cell with novel functions and/or capabilities;
- develop a common framework for characterizing and standardizing parts (functions);
- pursue orthogonality of function / parts (functions);
- establish a solid computational and modelling infrastructure.

A good summary of the achievements and promises of Synthetic Biology are the two EU publications "Synthetic Biology: Applying Engineering to Biology" of the high-level-expert group[1] and the brochure listing the ongoing SB projects in the NEST pathfinder program.[2]

Download of the presentation: http://www.tessy-europe.eu/public_docs/Science_Talk-Synthetic-Biology_10June2008.pdf

[1] Download:ftp://ftp.cordis.europa.eu/pub/nest/docs/5-nest-synthetic-080507.pdf

[2] Download: ftp://ftp.cordis.europa.eu/pub/nest/docs/syntheticbiology_b5_eur21796_en.pdf

3.2 Industrial Synthetic Biology – a glimpse on opportunities, challenges and responsibilities of an emergent industry

One of the companies that initiated activities in emergent field of Synthetic Biology is febit biotech GmbH in Heidelberg, Germany. Its co-founder Peer Stähler allowed an insight into the company perspective. Peer Stähler is the Vice President of febit biotech GmbH and responsible for the company's marketing & sales. As Chief Scientific Officer he is also in charge of the strategic product planning and, connected with this, of the supervision and coordination of febit's intellectual property, as well as of its further development aimed to protect the company's Biochip Technology by means of registered trademarks and patents. He studied biology at Konstanz University with the main focus on molecular genetics. In his diploma thesis he developed a reporter gene platform for non-invasive monitoring of genetic therapies at the German Cancer Research Centre (DKFZ) in Heidelberg. As a research scientist at Max Planck Institute for Brain Research (MPIH) in Frankfurt/Main, he was involved in different DNA analysis projects in Europe and in the USA. In 1998 he co-founded febit ag and has acted as its Chief Scientific Officer since then.

The febit group, formed Spring 2005 employs 70 employees in Heidelberg (Germany) and as febit Inc. 14 Employees in Boston (USA). Core competencies of febit are the development, manufacturing and marketing of a proprietary suite of microarrays, instruments and services. Core expertises are automated DNA microarray systems fusing microfluidics, digital light projection and in situ microarray synthesis. Products and services of febit are instruments, consumables, reagents, software, microarray application services, synthetic genes and key applications are Microarray Analysis, Transcriptome Profiling, Synthetic Biology.

Peer Stähler sees the opportunities of Synthetic Biology in a huge market: He assesses the genemarker market at 50 Mio EUR and the total cloning reagents and accessories market at 2 Billion EUR. Future opportunity for the researcher will be to replace the own cloning approach by "final solutions". Challenges in Synthetic Biology from industry perspective are

- the development of value added products,
- biosafety and biosecurity issues per se,
- biosafety and biosecurity concerns in the public and among policy makers,
- regulatory environment.

To address these challenges six companies dedicated to Synthetic Biology founded the Industry Association of Synthetic Biology (IASB). Their key goals are to promote Syn-

thetic Biology, address and manage biosecurity and biosafety questions, initiate international collaboration and interaction with government authorities. Provide education, information and training and establish fund raising to support activities. With these activities they comply with their responsibility to consciously work on safe side of risk-versus-chance balance in new application areas and support turning the potential of Synthetic Biology into reality – and commercially viable business.

Download of the presentation: http://www.tessy-europe.eu/public_docs/Industrial-Synthetic-Biology_10June2008.pdf

3.3 Synthetic Biology: responding to the social and ethical challenges

Insight into the social and ethical challenges of Synthetic Biology was given by Paul Martin. Paul Martin is Reader in Science and Technology Studies and Deputy Director of the Institute for Science and Society, University of Nottingham. He has two main area of research interest. The first is the ethical, legal and social issues associated with emerging medical biotechnologies. In 2005 he was appointed as a member of the Wellcome Trust's Biomedical Ethics Programme funding panel. The other main area of research focuses on the commercialisation of biotechnology and expectation dynamics in medial innovation. His research has been published in leading international journals, including, Nature Reviews Genetics, Trends in Genetics, British Medical Journal, Sociology of Health and Illness, Social Studies of Science, Research Policy and Bioethics. He is currently a member of the editorial boards of Sociology of Health and Illness and New Genetics and Society. Paul Martin has previously advised the European Parliament, the Conseil d'Analyse Economique (part of the French Prime Minister's Office) and the Department of Trade and Industry, and in 2004 was commissioned by the Royal Pharmaceutical Society to write a report on the development of genomic medicine. He is currently a member of a BBSRC working group on Synthetic Biology and has co-authored a review of the social and ethical issues raised by Synthetic Biology which was be published in June 2008. [3]

Paul Martin illustrated that the main areas of concern in Synthetic Biology are:

- Uncontrolled environmental release
- Biological weapons
- IP – creation of monopolies
- Trade and global justice

[3] Download of the Report: http://www.bbsrc.ac.uk/organisation/policies/reviews/scientific_areas/0806_synthetic_biology.pdf

- Creating artificial life

These anxieties are not new, however, the novel aspects of Synthetic Biology arise from the speed and low cost of DNA synthesis which facilitated biological engineering. A number of important lessons can be learnt from the history of recombinant DNA, including that it is essential for the scientific community to play a leadership role in addressing risks and ethical issues, introducing pre-emptive policy initiatives, applying tight regulation in the beginning which can be relaxed over time and stimulating open public debate. Key aspects of the debate about the governance and management of expectations in Synthetic Biology, have to be on the agenda over the coming months and years.

(A) Debate

The debate should demonstrate the responsibility of funders, the research community and industry and seek to build consensus. This can only be achieved if the science and technology does not get too far ahead of public opinion and that social benefits are clearly shown.

(B) Governance

The governance of Synthetic Biology has to find the right balance between self-governance and statutory regulation. Key areas of concern are the status of genetically modified or new organisms, and the threat by bio-weapons. In general, governance has to take place at multiple levels, i.e. international, regional, national, and local. Paul Martin mentioned a range of different mechanisms such as international treaties, national laws, professional guidelines, education and awareness rising.

(C) Management of Expectations

Currently there are high expectations of progress in the science and technology of Synthetic Biology. Though they are the key to mobilising resources and support, there is a need for realism, responsibility and reflection. The results of basic research Synthetic Biology should be translated into working technologies that are widely used and socially acceptable. But it has to be recognised that this is a slow process.

Download of the Presentation: http://www.tessy-europe.eu/public_docs/Synthetic-Biology-responding-to-social-and-ethical-challenges_10June2008.pdf

3.4 Synthetic Biology in KBBE

Ioannis Economidis is a scientific officer at the General-Directorate for Research of the European Commission. From this perspective he illustrated the Synthetic Biology activities of the EU. Ioannis Economidis has a background in Agronomy and Plant Pathology (Agricultural University of Athens, Greece (1968)) and he has a Ph.D in Biochemical Genetics from the Biology Division of the University of Texas at Austin, USA (1975). His main research interest was protein/nucleic acid interactions in gene regulation. He worked in the National Hellenic Research Foundation (Athens, GR), University of Thessaloniki (GR), Nuclear Research Centre “Demokritos” (Athens, GR), the Worchester Foundation for Experimental Biology (Shrewsbury, MA, USA), the Deutsches Krebsforschungszentrum (Heidelberg, Germany) and the International Institute of Molecular and Cellular Pathology (Brussels, Belgium). In 1987 he joined as scientific officer the General-Directorate for Research of the European Commission and he worked in the interface of issues of Biotechnology and the Environment. He managed activities dealing with the environmental safety of genetically modified organisms, topics related to environmental biotechnology and to microbial molecular diversity. He is representing frequently his service in OECD and other international fora. He is keeping his academic interests by giving graduate courses at the Technical University of Athens and the University of Crete, on the socioeconomic aspects of biotechnology.

Ioannis Economidis illustrated that there is international interest on the field. Recent activities were for example the EU-USA Synthetic Biology Workshop (April 2006) together with the US Department of Energy, a number of international meetings such as the ESF Workshop (Nov. 2007), the activities of funding organisations such as the Royal Society in the UK the uptake of an initiative by the OECD and some NGOs such as the ETC group (www.etcgroup.org/en/issues/synthetic_biology.html). Currently there are plans to examine issues of mutual interest and explore opportunities for transatlantic collaboration. Topics for a planned satellite meeting to the 2009 EU-US Task Force meeting will be science and engineering of standardization, biosafety/biosecurity, and transformative biotechnology applications of SB. Participants should be ten to 15 scientists and engineers from each side of the Atlantic.

After the NEST pathfinder activities on Synthetic Biology, the EU recently launched a call on SYNTHETIC BIOLOGY FOR THE ENVIRONMENT - The use of Synthetic Biology for the solution of environmental problems. The call was for a coordination and support action aiming at coordinating research activities. The chosen project will target environmental pollution with engineered microbial systems á la carte (TARPOL). The two-year project is carried out by 18 Partners and was started beginning of July 2008.

Download of the presentation: http://www.tessy-europe.eu/public_docs/EU-Talk_Synthetic-Biology-in-KBBE-kurz_10June2008.pdf

4 Strategy for Synthetic Biology

4.1 A roadmap for Synthetic Biology in Europe

As discussed in the morning session, the EU has started first measures to develop the field of Synthetic Biology. However, research activities are scattered across European regions and across scientific disciplines and are concentrated in a relatively small number of working groups. To overcome these obstacles the Specific Support Action TESSY (Towards a European Strategy for Synthetic Biology) was initiated by the European Commission which aims to fill this gap by setting up an expert based, investigative and participative process for the further development of SB in Europe. One of the core elements of TESSY is a roadmap for Synthetic Biology which was presented by Sibylle Gaisser, the project leader of the TESSY project.

Sibylle Gaisser studied bioprocess engineering, molecular biology, genetics and microbiology at the Universities of Stuttgart, Swansea and Freiburg, graduating in 1994 with a Master in Technical Biology at the University of Stuttgart. Her Diploma thesis dealt with the production of shikonin in plant cell cultures. In 1998 she received her PhD at the Eberhard-Karls-University Tübingen, Faculty of Pharmacy, for research in the field of modular antibiotic synthesis and resistance mechanisms in *Streptomyces*. From 1998-1999 she worked as the assistance of the CEO at the Biotechnology Agency Baden-Württemberg. In July 1999 she joined the Fraunhofer Institute Systems and Innovation Research as a Project Manager in the Competence Center 'Emerging Technologies'. Her main research interests are the sustainable development in biotechnology and the health sector; impacts of innovations in life sciences on society, economy and ecology, and improved knowledge transfer in life sciences.

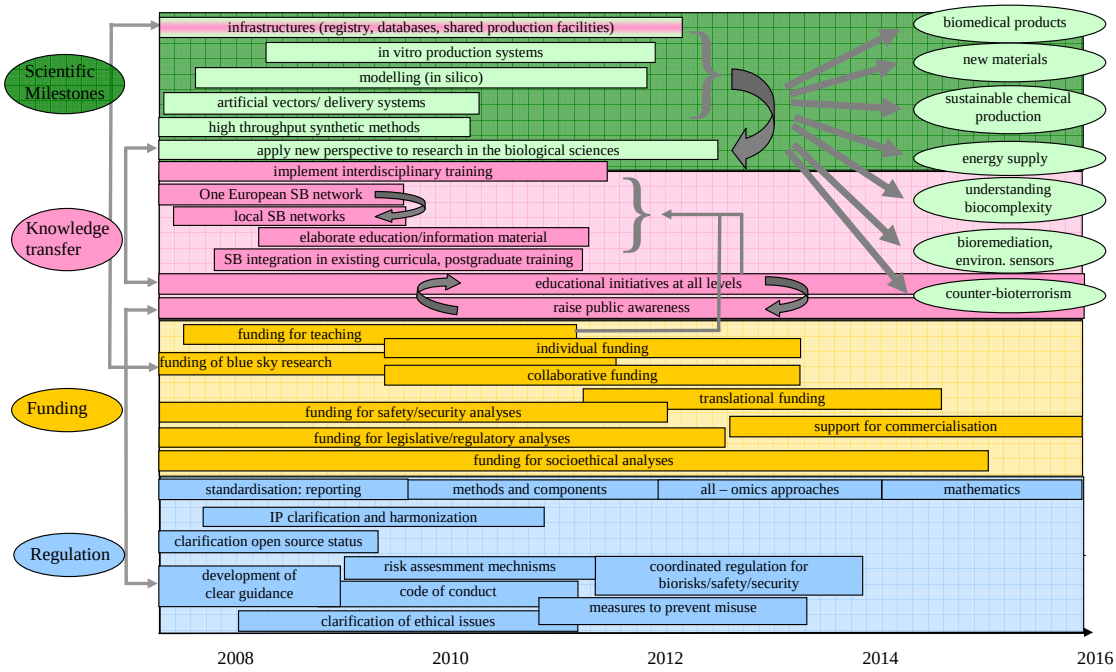
Synthetic Biology is a highly interdisciplinary research field involving the active participation of chemistry, computer science, biology, engineering sciences, material sciences and physics. Future success in Synthetic Biology depends upon

- a shared understanding of the underlying definition of the new technology,
- awareness of its potentials and achievements,
- involvement of all actors in the innovation system,

- an integrated strategy both on the European and national level,
- mobilisation of public and private resources on the European and national level.

An integrated strategy aims at the development of the four dimensions "Science", "Knowledge transfer", "Funding" and "Regulation" (Figure 1).

Figure 1: Roadmap Measures and Milestones towards a Successful European Synthetic Biology



In the dimension "regulation" very relevant activities with a short term perspective are the clarification of open source status and IP clarification and standardization. Activities that should be carried out with a short to mid term perspective are the clarification of ethical issues, the development of a code of conduct for SB research and of risk assessment mechanisms and a coordinated regulation of biorisks/biosecurity (Table 2).

Table 2: Milestones Regulation

activity	relevance factor	timing
clarification of open source status	3.13	short term
IP clarification and harmonization	3.03	short term
standardize components	3.0	short to mid term
measures to prevent misuse	2.9	mid term
coordinated regulation of biorisks/safety/security	2.9	mid term
clarification of ethical issues	2.78	short to mid term
code of conduct	2.76	short to mid term
risk assessment mechanims	2.6	short to mid term

Very relevant activities in the dimension "funding" from a mid term perspective is blue sky funding (bottom-up approach). Collaborative and individual funding (i.e. strategic activities of national funding bodies need some preparation and should be initiated within the next two years. Teaching is an essential part in the development of Synthetic Biology that should be started now and extended with a mid term perspective. Translation into the commercial sector is expected with a mid to long term perspective. Funding of context analyses (socio-ethical, legislative/regulatory, safety/security analyses) are assessed as being an integral part of Synthetic Biology development. Of the total amount of funding that is required to start and which was assessed to be in the range of 10 – 25 Mio €, experts estimated that 5 – 10 % of the budget could be dedicated to ELSA research/accompanying measures (Table 3).

Table 3: Milestones Funding

activity	relevance factor	timing
blue sky funding	3.7	short term
collaborative funding	3.38	short to mid term
individual funding	3.35	short to mid term
translational funding	3.08	mid to long term
funding for teaching	3.0	short to mid term
support for commercialisation	2.63	long term
funding for context analyses (socioethical, legislative/regulatory, safety/security)	2.6	short to long term

Knowledge transfer within the scientific community and with stakeholders of other groups (lay people, decision makers) is a prerequisite for the successful development of the highly interdisciplinary field of Synthetic Biology. Highest relevance with a short term perspective in this field have the implementation of interdisciplinary training, the

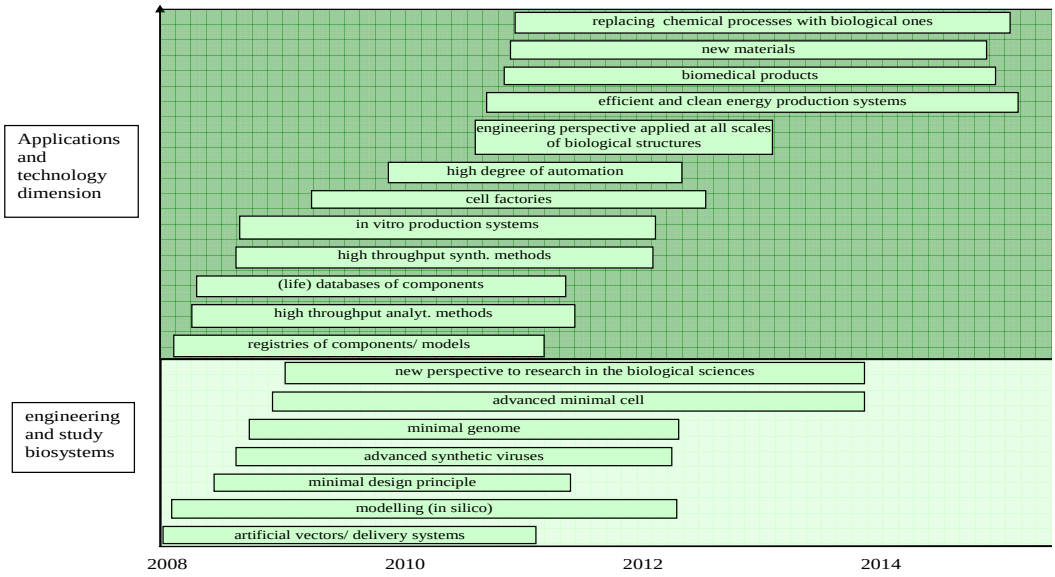
establishment of SB networks and the integration of Synthetic Biology in existing curricula. The elaboration of education and information material to raise awareness for Synthetic Biology at all levels is assessed as a continuous activity (Table 4).

Table 4: Milestones Knowledge Transfer

activity	relevance factor	timing
implement interdisciplinary training	3.37	short to mid term
establish SB networks	3.14	short term
SB integration in existing curricula	3.05	short to mid term
elaborate education/ information material	2.76	short to mid term
educational activities at all levels	2.66	short to long term
raise public awareness	2.62	short to long term

The scientific milestones in the roadmap follow a clear chronological order. However there was consensus that progress in science is dynamic and the determination of specific milestones are a "moving target"; especially as there are extensive research efforts also from private side the scientific advancement can be speeded up. Thus it is suggested to use the current scientific roadmap as a guideline for the strategic planning of research focus but it should be updated regularly according to latest state-of-the art in SB (Figure 2).

Figure 2: Chronological order of scientific milestones as projected in online survey December 2007



It could be shown during the roadmapping process that there are a number of activities with assessed high relevance (e.g. interdisciplinary training, funding, clear guidelines,

IP etc.) and high consent about early starting point of many activities (standard deviation ~2 years). The required time for each activity (end point) was assessed differently (standard deviation ~ 4.5 years). Additionally, the survey showed that the perceived relevance of an activity declines if the activity is further in the future. Similarly the consent about starting point declines if the starting point is further in the future (higher standard deviation). As a highly interdisciplinary approach Synthetic Biology requires concerted action in different dimensions to display its full strengths.

Download of the presentation: http://www.tessy-europe.eu/public_docs/Presentation-Roadmap_10June2008.pdf

4.2 Policy approaches to furthering Synthetic Biology

Thomas Reiss who has long term experience in the assessment of national and international policy measures gave an insight into possible approaches for furthering Synthetic Biology. He holds a PhD in Molecular Biology from Freiburg University (1983) and joined Fraunhofer ISI in 1987 as a project manager. Until 1993 he built up the biotechnology group at Fraunhofer ISI and became head of the new department “Innovations in Biotechnology” which developed into one of the leading research groups in Europe dealing with the analysis of innovations in biotechnology. Since 2005 Thomas Reiss is heading the new department "New and Emerging Technologies" which integrates Fraunhofer ISI's competences in life sciences, ICT and nanotechnology. The current research of Thomas Reiss is focusing on national and sectoral innovation systems, on industrial innovation, on monitoring and foresight of new technologies and on the evaluation of innovation policies.

Thomas Reiss presented the idea of evolutionary funding which could be helpful in integrating and supporting unexpected methodological approaches in Synthetic Biology research. Evolutionary funding is designed to fund projects that contribute to a certain desired outcome e.g. the provision of efficient energy systems. The selection of projects is carried out on basis of an assessment of the project's contribution to the outcomes rather than the *ex ante* assessment of the technology (by an international panel). The advantage of this type of funding is that it supports creativity and helps to draw also conclusion from approaches that do not succeed (tolerance to mistakes).

Additionally, Thomas Reiss pointed on the importance of industry in Synthetic Biology. Joint projects between industry and academia could be beneficial for future progress in Synthetic Biology. Another aspect is the already mentioned interdisciplinary character of Synthetic Biology. This feature confronts funding organisations with new challenges for example with respect to shared budgets across disciplines. It was suggested that an interdisciplinary strategy development could assist to overcome disciplinary borders

within funding agencies. In terms of fostering interdisciplinarity it seems also important to develop interdisciplinary criteria for evaluating academic success.

Thomas Reiss also emphasized the need for more European activities. Eurocores and the development of a European consortium in Synthetic Biology that represents an interdisciplinary network of competence and contributes to shared DNA analysis and synthesis capacities, shared computational facilities and a validated registry could be a step in this direction. The required manpower for an accompanying infrastructural measure could be 5-6 persons. Such an infrastructural measure could be attached to a European research institute such as the EMBL.

Measures on the legislative and social level could be the establishment of an international task force to clarify IP issues and the development of a participative process to deal with issues of the public.

Download of the presentation: http://www.tessy-europe.eu/public_docs/Policy-approaches_10June2008.pdf

4.3 Boosting Synthetic Biology in Europe – what is needed?

Moderated by Astrid Lunkes of the European Science Foundation Mattheo Bonifacio (Bureau of European Policy Advisers, BE), Amanda Collis (Biotechnology and Biological Sciences Research Council (BBSRC), UK), Leonard Katz (Synthetic Biology Engineering Research Center (SynBERC), US), Martin Reddington (Human Frontier Science Program Organisation (HFSPO), FR), Luis Serrano (Centre for Genomic Regulation (CRG), ES) and Daniel Vonder Mühll (SystemsX.ch, CH) discussed models of research funding in Synthetic Biology, approaches to foster interdisciplinarity and the challenges of academia-industry collaboration. In the beginning the panellist introduced themselves and their vision on Synthetic Biology (Figure 4).

4.3.1 Participants in the Panel Discussion

MATTEO BONIFACIO – Bureau of European Policy Advisers (BEPA), BE

Since January 1st 2008, Matteo Bonifacio is Policy Adviser at the Bureau of European Policy Advisers on research, higher education and innovation matters. The mission of the BEPA is to provide timely, informed, policy and political advice to the President and Commission Services on issues relevant to the President's agenda and the future of policies in the Union. The main activities of BEPA are to lead the reflection of new policies and suggest new possible policies in a very early stage. BEPA is involved in the development of cross-cutting research agendas with the involvement of European di-

rectorates and experienced stakeholders. Additional information is available from http://ec.europa.eu/dgs/policy_advisers/index_en.htm

From October 2005 to December 2007 he was Policy Developer at the European Commission in the Directorate General Education and Culture, operating in the unit dealing with school, education and higher education. There he was member of the team in charge for the development of the proposal to establish the European Institute of Technology (EIT) and has designed and implemented the call for proposals "Pilot projects for cooperation between European Institutes of Technology". The EIT aims at border crossing between disciplines and organizations and integrate business not just as clients but also in research. Matteo Bonifacio experienced a gap between academia and business, i.e. academia seems to work much in the business world, but there are only limited activities in the opposite direction. Additional information on the EIT is available from http://ec.europa.eu/eit/.

LEONARD KATZ – Synthetic Biology Engineering Research Center (SynBERC), US

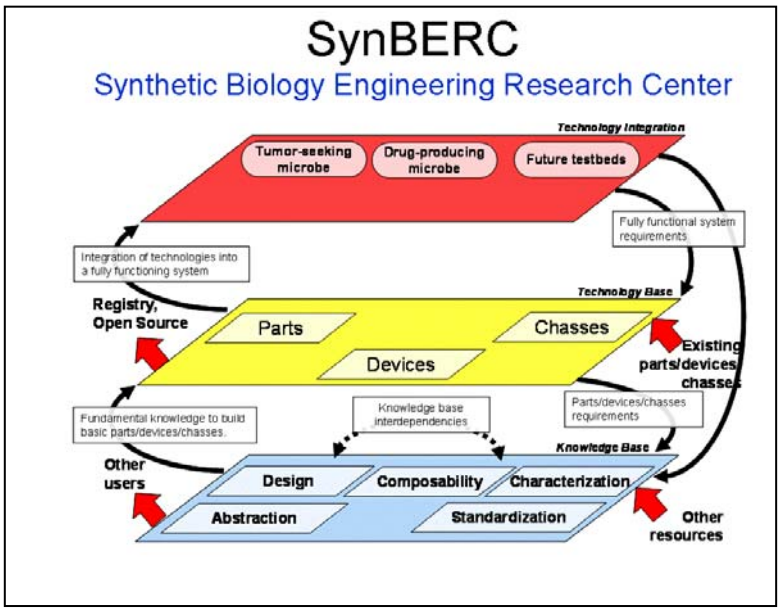
Leonard Katz is Research Director at SynBERC, a multi-institution research effort to lay the foundation for Synthetic Biology. At SynBERC, he heads the Center's Industry Affiliates Program, which aims to accelerate the commercial use of SynBERC's research developments. Previously, Leonard Katz was Vice-President, Biological Sciences, of KOSAN Biosciences, Inc. and spent 19 years at Abbott, where he held a series of research and research management positions. Prior to that, he was a Senior Scientist at Schering-Plough, Inc. between 1977 and 1979 and Assistant Professor in the Biology Department at New York University between 1974 and 1977. Leonard Katz's background is in microbiology and molecular genetics.

SynBERC has similar aims as TESSY in the public sector but it has a stronger link into the commercial sector with an Industry Advisory Board involved in the strategy planning and reviewing of the programme. However, additionally to the development of a conceptual framework for designing small biological components (parts) that can be assembled into devices that will perform a well-characterized function under specified conditions, SynBERC has a number of scientific goals. In detail this are:

- developing a small number of chassis (stable, robust bacterial hosts with known responses) to host the engineered devices and to assemble several devices to accomplish a larger vision or goal,
- developing a set of standards for the interactions of the parts and devices so that the devices can be built more readily and reproducibly,
- offering the parts, devices, and chassis as open source to other researchers and companies.

Additional information is accessible from http://www.synberc.org/. The structure and activities of SynBERC are summarized in figure 3.

Figure 3: SynBERC structure



Source: www.synberc.org

AMANDA COLLIS – Biotechnology and Biological Sciences Research Council (BBSRC), UK

Amanda Collis is Head of Tools and Resources, Biomolecular Sciences and Engineering and Biological Systems at the UK's Biotechnology and Biological Sciences Research Council (BBSRC). She joined BBSRC in 1998 and her employment has included two secondments, one to the Houses of Parliament (2001) and one to Research Councils UK (2002/3). Dr Collis has also worked with the Royal Botanic Gardens, Kew and has a background in molecular biology. The BBSRC has an annual budget of 380 Million Pound. It funds excellent cross-boarder research, master's trainings and knowledge transfer in new emerging technologies. It engages in the understanding and integration of public and societal issues and addresses this field with specific activities. The BBSRC sees in Synthetic Biology an important area at the intersection of engineering, biosciences, chemistry and mathematics which stimulated a number of surrounding activities such as the report on Ethical and social challenges of Synthetic Biology mentioned in the presentation of Paul Martin (see 3.3).The BBSRC was active in developing a research agenda in 2007 and started first funding activities of SB collaborations in the UK in 2008. Additional information is available on http://www.bbsrc.ac.uk/.

MARTIN REDDINGTON – Human Frontier Science Program Organisation (HFSPO), FR

Martin Reddington studied biochemistry at the University of Liverpool, UK and obtained a PhD in biochemistry from the Institute of Psychiatry, University of London in 1974. After a brief postdoctoral period at the University of London, he moved in 1975 to the Department of Neurochemistry at the Max Planck Institute of Psychiatry (now MPI for Neurobiology) in Munich, Germany. He transferred to the Department of Neuromorphology in 1977, where he remained until 1996. In 1996 he took up a position of Director of Fellowships at the Human Frontier Science Program Organization in Strasbourg, France, with responsibility for the postdoctoral fellowship program. From 1997 to 2000 he was Director of Research Grants and played a key role in the transformation of the project grants into a truly interdisciplinary program, as well as the introduction of online grant application submission and review technology. In 2000 he was appointed Director of Scientific Affairs and Communications and is now responsible for scientific issues spanning all the scientific programs and for promoting the HFSP in the scientific community. The funding of HFSPO is based on two pillars

1) funding on a postdoctoral level and people who want to go abroad. Long-term Fellowships provide young scientists with up to three years of postdoctoral research training in an outstanding laboratory in another country. The third year of the Long-Term Fellowship can be used either for repatriation to the Fellow's country or in the host laboratory. The fellowships provide approximately $US 45,000 per year, including allowances for travel and research expenses. Cross-Disciplinary Fellowships: Cross-disciplinary fellowships are intended for postdoctoral fellows with a Ph.D. degree in the physical sciences, chemistry, mathematics, engineering and computer sciences who wish to receive training in biology. The conditions are the same as for the Long-Term Fellowships. Short-term Fellowships enable researchers to move into new areas by learning state-of-the-art techniques in use abroad or by establishing new research collaborations. These fellowships can last from two weeks to three months in a foreign country.

2) programme grants which bring together laboratories and scientists of different countries and disciplines. Research grants are provided for teams of scientists from different countries who wish to combine their expertise to approach questions that could not be answered by individual laboratories. Emphasis is placed on novel collaborations that bring together scientists from different disciplines (e.g. from chemistry, physics, computer science, engineering) to focus on problems in the life sciences. Up to $450,000 per grant may be available per application.

HFSPO does not fund large networks but aims at the communication between scien-

tists and different disciplines. Especially for emerging technologies it is important that funders "jump over their shadow" and take risks. Additional information is available at http://www.hfsp.org/.

LUIS SERRANO – Centre for Genomic Regulation (CRG), ES

Luis Serrano is director of the Systems Biology Research Unit at the Centre for Genomic Regulation in Barcelona, Spain. The CRG has a strong Biocomputing programme that could cover the data gathering and the comparative genomics, thus it is put more emphasis on data integration, computer modeling and experimental validations as well as on the design aspect. Research will draw on the expertise of various scientific disciplines and will span the entire range from molecules to cells. The four multidisciplinary groups will work with a variety of research techniques, including RNA interference, biochemical networks and mouse development. With the formation of the partnership between EMBL and the Centre for Genomic Regulation (CRG), financed by the Spanish Ministry of Education and Science (MEC), these institutes are set to advance the understanding of complex biological systems. This partnership combines EMBL's expertise in computational biology with the CRG's know-how in specific areas of genomics and proteomics and will allow to better understand some of the key aspects of human health. Luis Serrano spent 12 years at European Molecular Biology Laboratory (EMBL) in Germany, where he held the position of director of the Structural and Computational Biology Programme between 2001 and 2006 and group leader between 1992 and 2001. Luis Serrano is scientific founder and member of scientific advisory boards of several biotech companies. His background is in protein biochemistry. Additional information on the CRG is available from http://pasteur.crg.es.

DANIEL VONDER MÜHLL – SystemsX.ch, CH

Daniel Vonder Mühll is Managing Director of SystemsX.ch in Zurich, a Swiss initiative dedicated to promote Systems Biology by combining Switzerland’s strengths in genomics and biomedical research with its flourishing core sciences as chemistry, mathematics, physics and engineering. Between 2000 and 2006, he was Head Research Management of the Rectorate at the University of Basel. Vonder Mühll is geophysicist and did a PhD about mountain permafrost at ETH Zurich. He was active as a PI in a number of permafrost research projects, e.g. an interdisciplinary EU-funded project and has been lecturer at ETH Zurich and University of Zurich. In 2001/2002, he did a postgraduate in “University Politics and Research Management”. SystemsX.ch is a top-down approach initiated by politics to stimulate the important field of Systems Biology by funding. SystemsX.ch is funded with a federal budget of CHF 100 Mio for the period of 2008 - 2011. Federal money is available only on a matching funds basis, meaning that the partners have to invest the same sum themselves in order to receive funds.

This way the total investment in Systems Biology will be at least CHF 200 Mio for 2008 – 2011, supplemented by third-party funds by industry and other funding agencies (competitive research grants like EU, CTI, NH). Currently eight ambitious research projects are funded integrating 79 groups at 11 Swiss universities and research institutions. It is expected to get closer collaboration with industry in the future. Additional information is available from http://www.systemsx.ch/.

Figure 4: Panel Discussion

4.3.2 Results of the Panel Discussion

As seen during the day one of the key characteristics of Synthetic Biology is its high degree of interdisciplinarity. The panelists agreed that organisation of funding has to address this specificity e.g. by the creation of a culture that fosters interdisciplinary interaction (as shown by HFSPO), information, and interdisciplinary evaluation. In these interdisciplinary evaluation panels the interdisciplinary role of the evaluator must be clear, which means that they assess the proposal as whole instead of few subparts from the disciplinary perspective. SystemsX.CH had good experience in outsourcing the evaluation process to the Swiss National Center and short 10 min presentations accompanied by 10 min discussions of all proposed projects. It was suggested to initiate funding based on challenges (e.g. ageing, climate change) independently from the scientific approach and to include social science in hard science projects. Mechanisms for funding could be pilot studies/projects which are useful for work with high failure rate or at high risk, and networks which should not be too large. On the other hand it was suggested that even different organizations with different background could collaborate (e.g. synthetic biology, systems biology, protein folders, neurosciences,…). The main focus of all networks should be to foster communication between scientists

and disciplines. Interdisciplinary research evaluation has to apply different criteria for evaluation as strongly disciplinary research and there is a need for publication fora.

Against the background of the discussion of basic versus applied research it was discussed that both directions should be more systematically connected and not separated too much. In general, it was argued that researchers should live and work in an environment where failures are accepted. Both researchers and funders should accept to take risks. Innovation could be fostered by an improved investment in people, by more involvement of doctorates with senior stakeholders, training and briefing of researchers and PhD students, and systematic supervision of a PhD thesis by two supervisors from different disciplines. It was suggested to reward more new excellent ideas and to give more money to excellent people. From the US experience Leonard Katz suggested that the commercial sector should be involved in decision making, training and implementation/risk management. The complementary skills of business are needed in the development of Synthetic Biology.

The US experience showed also the relevance of ELSI (=ethical, legal, social issues) research. At SynBERK two out of 16 professors deal with ELSI questions. The close cooperation and involvement was not easy in the beginning but now it works well as reported by Leonard Katz. Daniel Vonder Mühll illustrated that another possibility to address public aspects of Synthetic Biology could be a participative approach as it is carried out in Switzerland with the "Buergerforen" (= *Citizens' fora*).

The discussion with the audience put an emphasis on the perspectives for future Synthetic Biology research. It was discussed that Synthetic Biology is still a risky field for research. The advantage of the European NEST programme was that it dealt with these risky fields. Future funding should extend this short term investment into a long term commitment by taking into account the situation of young scientists. Funding should create a certain freedom of research and contribute to the sustainable development of the field of Synthetic Biology.

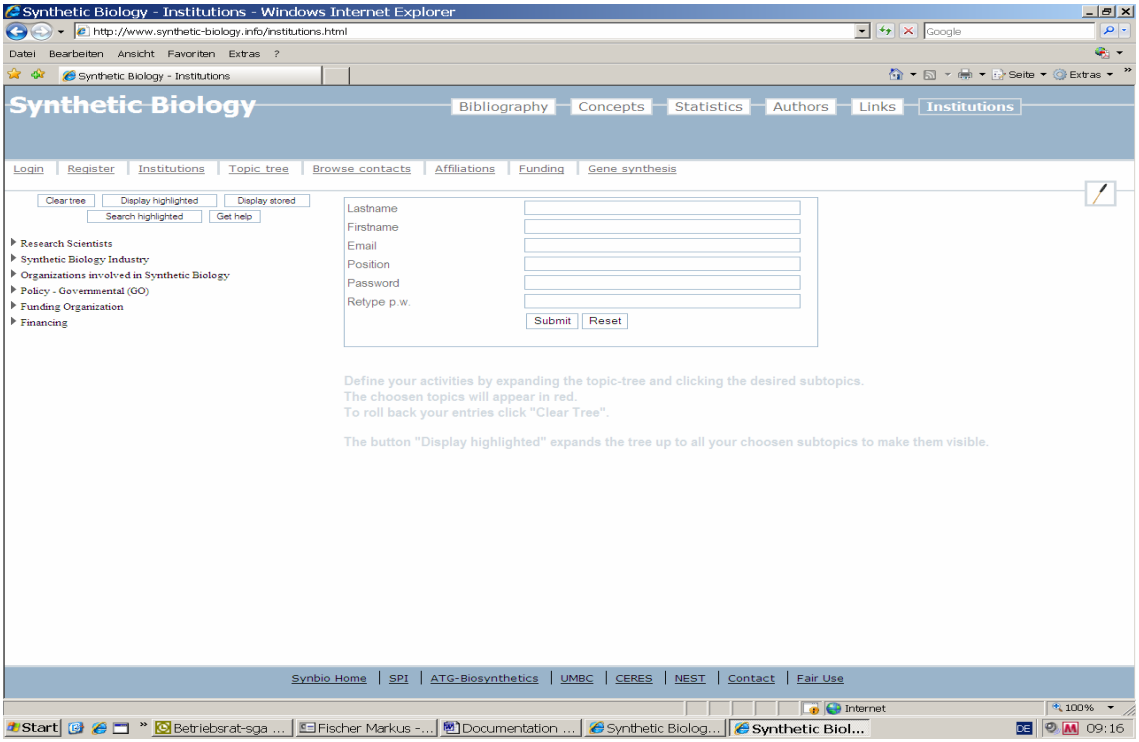
5 Conclusions

With high level experts and a very interactive and communicative audience the meeting was a successful and motivating signal for future activities in Synthetic Biology. It became obvious that Synthetic Biology is a highly interdisciplinary field with a high challenge and potential for knowledge integration. In order to promote the field from a technological perspective, integration needs to be achieved at the intersection of natural science, engineering and industry. Integration of the public in a broader sense i.e. both lay people and decision makers is an additional challenge to develop the field in accordance with public needs and within generally accepted framework conditions. Sustainability in Synthetic Biology could be achieved by involving different (funding) actors on an institutional, national and international level in Synthetic Biology. The uptake of an evolutionary funding strategy that aims at addressing general challenges (e.g. energy requirement of the future) could support creativity and allow the establishment of cross-sectional research alliances. This strategy could stimulate research and funding strategies that integrate complementary skills of the industrial sector and direct research towards future markets. Under this perspective funding organisations should keep in mind the expected need for translational money within the next five years.

The TESSY project will develop a self-assessment tool that helps the institutions to assess their current situation and develop a targeted strategy. The tool and best-practice examples will be presented in a meeting in November 2008. All actors (academia, industry, funding agencies) are invited to register in the Synthetic Biology Database which will be a basis for future strategy development and collaboration (http://www.synthetic-biology.info/institutions.html) (Figure 5). Start the registration procedure by clicking the "Register" button. You can easily define your activities by expanding the topic-tree and clicking the desired subtopics. The chosen topics will appear in red. To roll back your entries click "Clear Tree". The button "Display highlighted" expands the tree up to all your chosen subtopics to make them visible (Figure 6). After the first registration you can supplement your profile by logging in with your email address and your password. You can browse the database by clicking the rotating magnifying glass.

Figure 5: Database on Synthetic Biology Actors and Institution; http://www.synthetic-biology.info/institutions.html

Figure 6: Registration Form



6 Annex

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6.2 Abbreviations

Abbreviation	Full Form
BBSRC	Biotechnology and Biological Sciences Research Council
BEPA	Bureau of European Policy Advisers
CEO	Chief Executive Officer
CRG	Centre for Genomic Regulation
CSIC	Spanish Scientific Research Council
EIT	European Institute of Technology
ELSI	ethical, legal, social issues
EMBL	European Molecular Biology Laboratories
ESF	European Science Foundation
HFSPO	Human Frontier Science Program Organization
HZI	Helmholtz Centre for Infection Research
IASB	International Association of Synthetic Biology
ICT	Information and Communication Technologies
IP	Intellectual Property
ISI	Fraunhofer Institute for Systems and Innovation Research
KBBE	Knowledge Based Bio-economy in Europe
MEC	Spanish Ministry of Education and Science
NEST	New and emerging science and technologies
OECD	Organisation of economic cooperation and development
SB	Synthetic Biology
SynBERC	Synthetic Biology Engineering Research Center
TESSY	Towards a European Strategy for Synthetic Biology