Towards a European Strategy
for Synthetic Biology

TESSY Deliverable D2.3:

Concepts to approach the roadmap goals

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Content

1 Introduction

Synthetic Biology (SB) is an emerging interdisciplinary approach in biology that aims at the combination of science and engineering in order to understand, design and build novel biological functions and systems. It is based on a number of enabling technologies such as the large scale analysis and synthetis of DNA, the deep understanding of biological processes and the ability of in-silico-modeling of biological processes. This requires a close cooperation of researchers with different scientific and cultural background such as biology, chemistry, engineering and computer sciences, physics and electronics. On the other hand SB is still in an early developmental stage with broad industrial applications in a medium to longterm perspective (minimum 10 years). These aspects have strong impact on the type, process and organisation of future funding and stimulating activities in SB. A first concept for such activities as basis for a discourse among public decision-makers, private and public funders scientist and industry is outlined in this paper.

2 Background considerations

The nature of SB as an interdisciplinary and early-stage scientific research field leads to a number of requirements that have to be considered in the development of stimulating measures.

- Traditional research funding is organized mainly along classical disciplinary borders. Funding approaches for SB need to consider the highly interdisciplinary character of SB and should be designed as cross-border activities supporting the integration of expertise from all involved disciplines and their synergetic potential.
- SB is in an early developmental stage. Thus the SB community is rather small and presently there is a rather high uncertainty about the future paths of SB. As a consequence it is difficult to identify all relevant disciplines required for establishing leading edge SB and it is highly likely that a single European country would not be able to provide all the required expertise at highest level. Accordingly a collaborative European approach in research taking advantage of specializations of different European countries seems suited best for promoting SB. Funders across Europe could get together to support interdisciplinary science for which the expertise is scattered in Europe.
- The term Synthetic Biology in its present understanding was established by a number of US institutes. Their understanding of SB is exclusively focused on the development

of new products and processes by the engineered assembly of biological parts and devices. The European SB community adds another view to this field delineation. SB results can also serve in basic science to get insight into the origin of life and the understanding of life processes. This broader understanding of SB has to be considered in the development of funding approaches.

- Europe has an excellent knowledge base in the relevant scientific areas such as biology, engineering snd computer science, chemistry, microelectronics etc.. However, translation of scientific results into commercial products is often hindered due to unefficient linkage between the public and the commercial sector. Reasons can be attributed to relatively poor mobility between the public and the private sector, to less funding of high risk commercial development and to some deficits with respect to the reception and translation of research results in the commercial sector. Common projects between academic research and industry or projects that are funded to a large extend by industry (see for example the BP investment in EBI (=Energy Biosciences Institute at the University of California, Berkeley) are quite frequent elsewhere e.g. in the US while such collaborations happen at a lower scale in Europe. This gap between basic sciences and application needs to be addressed and the specific European situation should be considered by specific translational initiatives.

First measures to address research questions and community building in SB have been initiated by the European commission. Additionally the BBSRC has started a networking initiative in SB in the UK. In order to stimuate the development in SB and achieve the roadmap goals an additional set of linked actions on national and European level could be helpful.

3 Roadmap Goals

The European Roadmap for Synthetic Biology revealed four dimensions for future progress in synthetic biology.

Dimension 1: Engineering and study biosystems

This dimension deals with the elaboration of a basic understanding of life processes. It involves theoretical analysis in biology, physics and chemistry. A possible spin-off of this dimension is the characteriszation and description of new parts and devices. The research within this dimension aims at a new perspective into biological science and the elucidation of biological processes.

Dimension 2: Development of methods and technologies

This dimension provides the relevant enabling technologies that are required to analyse and synthesise biological molecules such as DNA, proteins and sugars. It is the basis for the production of parts and devices. The research within this dimension aims at the provision of those technologies that allow the application of the engineering perspective at all scales of biological structures and processes.

Dimension 3: Applications

This dimension provides the standardardization procedures and database requirements to translate and commercialize the concept of parts and devices into commercial products and processes. The research within this dimension aims at new materials, biochemical products, efficient energy systems and biological production processes etc.

Dimension 4: Public dimension

This dimension embeds and links the scientific and commercial activities related to SB with the socio-political context. It aims at the creation of favourable framework conditions (e.g. in the field of IP), the clarification of ethical issues and the provision of clear guidelines for the exploitation of Synthetic Biology. The goal of dimension 4 is a broad consensus on use and handling of SB.

4 Concepts to achieve the roadmap goals

It is proposed to address the roadmap goals by a set of different measures that can be assigned to three modules. National specialities and strenghts in a subfield of SB, which are already covered by specific supporting measures may suggest to focus on these specific thematic activities and integrate SB measures into these thematic activitiess. E.g. existing national strategies in white biotechnology may lead to the development of a SB strategy within programmes specific for white biotechnology. However, also with a more focused approach on a specific field of applications in SB the development of measures in all four modules described below should be considered. Additionally it should be assured from a European perspective that different national competencies in specific application fields are bundled at the end of the day and the achievements in e.g. technology development in one subfield is made available to all SB application fields.

4.1 Funding instruments

Due to the early developmental stage of SB a strong focus on specific thematic areas with defined milestones and goals could hinder explorative and creative research and the exploitation of non-intended and/or non-predicable results. It is important to explore various options and do not confine research activities too early to a limited number of (from the present perspective) promising avenues. The challenge is to avoid look-in effects on the one hand and enable effective research on the other hand. It is suggested to apply additionally to classical blue sky research an evolutionary funding scheme that allows the funding of projects which are designed to contribute to a certain desired outcome e.g. the provision of efficient energy systems. This approach allows the adoption of creative and unconventional ideas (explorative projects) as the selection is based on an assessment of their contribution to the outcomes rather than the *ex ante* assessment of the technology. Within such a scheme the quality of the selection procedure is crucial. Therefore a high level international panel would be well suited for such a task. This panel would also have the task to elaborate recommendations for the adjustement of funding activities according to the achieved results. Such an evolutionary funding approach would not only support creativity but could be helpful to draw also conclusion from approaches that do not succeed. It increases the tolerance to mistakes, as "negative" results are also helpful to advance the field.

Europe has a certain deficit in translation of public research results into the commercial sector. In order to avoid this "European paradox" in SB already at the current early stage of the field industry's interest for SB should be raised. This could be achieved e.g. by funding instruments supporting joint projects between industry and acaedmia. A flexible approach to such joint ventures in a sense that flexible rules for financial contributions of industry might be adequate for the field. Measures that spotlight the best examples of cooperation between industry and science could be a stimulus for other collaborations.

Funding of SB requires an interdisciplinary approach also in funding agencies. The current situation of disciplinary responsibilities in funding agencies is an obstacle to efficient SB funding strategy. Thus shared budgets and interdisciplinary strategy development should assist to overcome disciplinary boarders within funding agencies. This would require also an interdisiplinary teaching of funders and reviewers. As the SB community in Europe is rather small with limited availability of all competencies in all nations an independent international panel for the evaluation of project proposals on a national level should be established. This

could be mediated by the ESF and their partners by SB funding activities within the EUROCORES programme.

SB development relies on the collaboration of different disciplines and requires large scale computational facilities. A European consortium could be helpful to provide all required facilities. This could be achieved by an interdisciplinary network of competence to link engineering, computer sciences, chemistry and life science and overcome national weaknesses. Currently, the majority of experts argued against a central SB institution as synthetic biology seems to be not mature enough. However, shared DNA analysis and synthesis capacities, computational facilities and a validated registry that could be attached to a European research institute such as the EMBL with a capacity of 5-6 persons are suggested as strong impetus for SB in Europe.

4.2 Topics of funding

Topics of funding can be categorized into two classes: (a) the funding of platforms of technologies and methods and (b) basic research. They form a basis for future knowledge and/or processes and applications in SB and allow the development of efficient enabling technologies. Among them is technology and methodology development in anaylsis and synthesis of building blocks and their polymers such as DNA, RNA, amino acids and sugars. Part of technology development are automation strategies as means to increase throughput rate.

On the other hand the analysis of biological processes to understand origin of life is helpful to provide the science base. Research that deals with minimal design priniciples, minimal genome and minimal cells and their modelling in silico will help in the design of particle, devices and production platforms.

4.3 Legislative and social measures

A shared understanding of standardization of parts and devices and the clarification of IP is necessary for enhancing the European competiveness of SB both within Europe and on an international level. These aspects should be solved by an international task force.

Community awareness is a matter of national and European actors. Public and private initiatives should collaborate to develop a participative approach that leads to a broad

consensus on use and handling of SB. Measures could be Internet-mediated as it was carried out e.g. in the German bioethic debate (www.1000fragen.de) and accompanied by citizens' panels as successful shown in the "Meeting of Minds" project, a European citizens' deliberation on brain sciences (http://www.meetingmindseurope.org).

A third domain of action in this module deals with the provision of adequate education in SB. This addresses the establishment of new curricula for SB and/or advanced training. The buildup of an interdisciplinary knowledge base could be stimulated by a facilitated exchange of scientists and students between disciplines. Such interdisiplinary activities are hindered by the established systems for evaluating scientific excellence and academic carrreers which are organized mainly along traditional disciplines. Therfore trying to establish also some interdisciplinary criteria for evaluating academic success in SB would be very importnat.

5 Conclusions

Synthetic biology as a new research field that combines an number of disciplines such as biology, computer sciences, chemistry and engineering requires creative support mechanismns and interdescipliary approaches for future success. The early developmental stage of SB could profit from evolutionary schemes in funding.

Currently SB deals with different aspects, some of them can be addressed within existing (funding) programmes or organisatorial instruments as a "sub-speciality", others require new infrastructural and funding instruments or legislative measures. For example issues such as new biological processes to replace chemical processes are already addressed in a a number of white biotechnology /metabolic engineering funding programmes. Future activities should include and emphasize SB related approaches in this area of research. The buildup of a validated and standardized registry or high-throughput synthetis capacities are currently not addressed as (strong) issue in funding. With this respect new initiative have to be established to foster future progress in SB.

6 Next steps

The suggestions of this working paper will form the basis for detailed discussions with the advisory board of the TESSY project and will feed in the self-assessment tool for funding organisations.