



**UK Synthetic Biology Leadership Council
2014 Open Meeting
Thursday 27th November 2014**

Royal Academy of Engineering

Prince Philip House, 3 Carlton House Terrace, London SW1Y 5DG

Attendees:

George Freeman MP	Department for Business, Innovation & Skills and Department of Health (attended from 15:00)
Prof Lionel Clarke	Co-Chair, SBLC
Prof Richard Kitney	Imperial College London
Prof Joyce Tait	Innogen Institute University of Edinburgh
Dr David Tew	GSK
Dr Rowan McKibbin	RCUK (attending on behalf of Dr Amanda Collis)
Dr Tim Fell	BioIndustries Association and Synthace
Prof Tim Dafforn	Department for Business, Innovation & Skills and University of Birmingham
Sue Dunkerton	Knowledge Transfer Network
Dr Chris Jones	Innovate UK
Mike Edbury	Government Office for Science
Tim Higginson	Department for Business, Innovation & Skills
Sarah Cundy	Defra
Dr Amy Tayler	Knowledge Transfer Network and Synthetic Biology Special Interest Group
Dr James Brown	Knowledge Transfer Network and Synthetic Biology Special Interest Group

Apologies:

Prof Dale Sanders	John Innes Centre
Prof Dame Janet Thornton	EBI
Prof Janet Bainbridge	UKTI
Dr Amanda Collis	RCUK (Dr Rowan McKibbin is attending on her behalf)
Alastair Kent	Genetic Alliance UK

Invited speakers:

Dr Alan Burbidge	Nottingham SBRC
Dr Jim Haseloff	OpenPlant SBRC
Dr Paul Race	Bristol SBRC

Dr François Képès	GIP Genopole
Eric Guittet	Directorate General for Research and Innovation, Ministry of Higher Education and Research, France
iGEM runners-up 2014	Imperial College London

Registered observers:

Simon Blows	The IET
Georgia Bondy	University College London
Linda Brooks	ThermoFisher
Stephen Chambers	SynbiCITE
John Collins	SynbiCITE
Tom Ellis	Imperial College London
Edoardo Gianni	University College London
Veena Gupta	The IET
Sarah Hartley	University of Nottingham
Vic Helm	Walnut Wearable Computing
Roland Jackson	Sciencewise
Tim Leeder	University of Bristol
Ceri Lyn-Adams	BBSRC
Claire Marris	King's College London
Rob Meckin	University of Sheffield
Wouter Muelema	Illumina Inc.
Paul Oldham	One World Analytics
Kedar Pandya	EPSRC
Vitor Pinheiro	University College London
Michael Reinsborough	KCL
Alec Robertson	4d-dynamics.net
Nick Rollings	Cambridge Consultants
Nigel Sansom	Faculty of Medical Science, Anglia Ruskin University
Charles Secrett	The Robertsbridge Group
Kathleen Sedgley	University of Bristol
Claire Spreadbury	University of Bristol
Lalitha Sundaram	University of Cambridge
Alasdair Taylor	The Royal Society
Bethan Wolfenden	UCL

1 Welcome & Introduction

Prof Lionel Clarke formally welcomed everyone to the meeting, explaining that the SBLC is committed to three meetings per annum, one of which is open. The planned format for this open meeting, which differs from 2013, is to have one hour in boardroom-style to cover internal council business, followed by a theatre-style showcase with invited speakers bringing us up to date on UK and international activities. Each session has time allocated for Q&A. George Freeman MP, Parliamentary Undersecretary of State for Life Sciences, will join us from 15:00.

Prof Lionel Clarke noted that is almost exactly three years since the process for developing a UK roadmap for synthetic biology was initiated, and two years since the formation of the leadership council. The roadmap provides a 20-30 year vision with a series of short-term recommendations, against which progress has been made. The overview provided by today's meeting will be used as a springboard to take stock of progress against the UK roadmap, to consider what activities are working well and where we need to focus future efforts. The UK scientific work must be expanded and a framework established to accelerate commercialisation to allow the field to move forward at an appropriate pace to deliver the benefits it promises. The wider community will be invited to take part in a range of activities, interactions and consultations regarding such a framework in the next few months.

The members of the SBLC introduced themselves. Lionel noted the apologies as above.

2 SBLC Internal Business

The actions arising from the last meeting (SBLC6, 3rd July 2014) are available in Annex 1. Actions 6-1, 6-2, 6-5, 6-15, 6-16, and 6-17 were noted as done/ongoing with no further comment. Action 6-14 will be covered under agenda item 10. Action 6-18 will be covered under item 5. Updates were provided on the following actions:

Action 6-3: Helen Bodmer and Shami Ahmed to consult Sharon Ellis before asking Julian Jackson (Defra) to (i) share Defra's response with the SBLC (ii) have another telecom with any interested members of the SBLC.

The recruitment of Sarah Cundy (Defra) to the SBLC is a positive step to better facilitate joint working regarding the implementation of the Nagoya Protocol and the Convention of Biological Diversity (CBD). The parties and signatories of the Nagoya Protocol must still work to reach a consensus. Defra will continue to update the SBLC.

Action 6-4: Richard Kitney and the science and technology sub-group to consider the EU consultation regarding the definition of synthetic biology.

Although the UK roadmap has a clear definition for synthetic biology, other parties, including the EU, continue to use a range of definitions, which although context specific can prove problematic. There are some concerns over the most recent proposed definition: for instance, it focuses on living cells, excluding cell-free aspects of synthetic biology. There will likely be another round of consultation, and the science & technology sub-group will be sure to contribute again.

Action 7-1: Prof Richard Kitney to direct the science and technology sub-group in preparing a paper regarding the definitions of synthetic biology for the next SBLC meeting.

Action 6-6: James Brown to finalise a logo for UK synthetic biology activities and provide guidelines for use.

The UK roadmap has provided a valuable central description of activities in the UK. UK branding for synthetic biology could be extremely valuable. The logo on page 1, which has been designed to work

in harmony with UKTI branding, can be accompanied by different text to represent other UK synthetic biology activities, not just the SBLC.

Action 7-2: Dr James Brown to make branding UK synthetic biology branding available with guidance for use.

Action 6-7: Richard Kitney, David Tew, Janet Thornton, Amanda Collis and Joyce Tait to consider how synthetic biology might be applied to a grand challenge, for presentation at the next SBLC meeting.

Since synthetic biology is such a broad discipline with a range of potential application areas, the SBLC considers it quite risky to focus on just one grand challenge: it may be more useful to exemplify how the field has potential in a range of applications. The ongoing consultation process will provide the SBLC and wider community to work together to create a range of opportunities.

Action 7-3: Dr James Brown and Prof Lionel Clarke to collate views from the consultation in time for the next SBLC meeting.

Action 6-8: Lionel Clarke to invite the selected nominees to join the SBLC governance sub-group.

The SBLC is deliberately a small group with individuals representing broader communities. The broader membership of the governance sub-group makes up for the SBLC's lack of depth and breadth. The SBLC wishes to appoint two additional members to the governance sub-group, representing broader societal perspectives. A recent invitation was turned down due to other commitments. Further invitations will be made and announcements made on the SBLC website as and when they are accepted.

Action 7-4: Prof Lionel Clarke and Prof Joyce Tait to fill the outstanding positions on the SBLC governance sub-group and to report back at the next SBLC meeting.

Action 6-9: Secretariat (KTN and BIS) and relevant UK Government Departments to look out for future UK, EU, UN and OECD consultations (which often come through a Government department) and to seek opportunities for the SBLC and its Governance subgroup to be engaged at an earlier stage wherever possible and appropriate.

The SBLC recognises the importance of such consultations, and representatives from Defra, HSE, other organisations and Government departments are encouraged to consult the SBLC in a timely manner to enable the busy members of the SBLC to respond and for the responses to be effectively convened. In most cases to date, the SBLC has been able to respond, although occasionally the response has come from individuals rather than the SBLC as a whole.

The SBLC, the SynBio SIG and the wider Knowledge Transfer Network (KTN) strive to be useful to Government departments, and whilst SBLC members and secretariat try to anticipate what might come through, longer lead times would be greatly appreciated: early, vague warning is often better than late, precise warning. The SBLC supports the SBLC secretariat in sending indicative expert

member responses in preference to no response at all, and even responses saying that sufficient time has not been provided, as appropriate.

Defra and the HSE are now represented on the SBLC and SBLC governance sub-group respectively, which facilitates the involvement of the SBLC in relevant discussions. The SBLC can be considered a first source of advice while consultations are under development, as SBLC members will be able to reflect the concerns of the community.

Action 7-5: All SBLC members, observers and secretariat to send consultation and calls for responses to the SBLC co-chair (Prof Lionel Clarke), the Governance Subgroup Chair (Prof Joyce Tait), and the SBLC secretariat (Dr James Brown and Dr Amy Tayler) in a timely manner.

Action: 7-6: On occasions when the SBLC is unable to respond to a consultation, SBLC Secretariat to reply stating that the lead-time is insufficient.

A recent HSE survey on synthetic biology was circulated via the Synthetic Biology Special Interest Group (SynBio SIG). The HSE representative is encouraged to report the results via the governance sub-group. The SynBio SIG, which was established to support the UK synthetic biology community in response to one of the recommendations in the synthetic biology roadmap, will likely survey the wider community in the upcoming consultation regarding next steps.

Action 6-10: Shami Ahmed to check the deadline for responses to the pro-regulation innovation framework, and Joyce Tait to coordinate a joint response on behalf of the SBLC governance sub-group.

The SBLC governance sub-group was unable to respond formally due to short timescales and other commitments, such as responses regarding the CBD and implementation of the Nagoya Protocol. However, Joyce Tait has contributed to EU decision making on this subject in other ways, such as speaking at the European Risk Forum. The SBLC and SBLC governance sub-group hope to respond should the opportunity arise again in the future.

Michael Edbury (Government Office for Science) noted that new technologies will play a key role in addressing pressing social-economic issues, but they have associated challenges. As such, the EU is currently host to a number of innovation initiatives. Prof Sir Mark Walport (Government Chief Scientific Adviser and Head of the Government Office for Science) recently published his first annual report, in which he described different ways to manage (not avoid) risk. Joyce Tait wrote one of the chapters in this report and Lionel Clarke provided an example from the field of synthetic biology. The European Risk Forum published an Innovation Principle on 4th November 2014, in which it puts forward an idea of pro-innovation as a counterweight of the precautionary principal, stating that innovation and risk should be considered equally in risk-related decision-making.

Action 6-11: Richard Kitney, Amanda Collis and Joyce Tait to summarise current activities concerning biosecurity for use at a policy meeting in October 2014.

At a UK trade mission to San Francisco in November 2013, it became evident that the US is developing biosecurity measures from which the UK could learn and benefit. For example, members of the FBI and Homeland Security, who are often highly trained scientists, engage with the US synthetic biology community. In October 2014, 12 US delegates travelled to London to take part in a UK-US policy meeting to discuss biosecurity and the development of a framework to support the burgeoning bioeconomy. The discussion concluded that formal processes are not sufficient, but that there is enormous value in engaging the community of practitioners, making biosecurity part of responsible innovation, and making it part of standard training practise. A report of the UK-US policy meeting, a draft of which has already been circulated around the participants and SBLC, will be published shortly.

Action 7-7: SBLC members to provide feedback on draft report of the UK-US policy meeting to Prof Lionel Clarke in the coming fortnight.

Prof Richard Kitney highlighted the importance of biosecurity issues and gave three examples of ongoing work in the field, emphasising that this activity demonstrates a lack of complacency in the UK: (i) the Blackett enquiry, a 6-month study chaired by the chief scientist; (ii) King's College London hosted a biosecurity workshop, a report of which is available online, and there is interest in running further open meetings with wider stakeholders including the public, journalists and scientists; and (iii) a UK-US collaboration. None of these enquiries have yet identified a significant threat from synthetic biology, but the field must be evaluated carefully and on an on-going basis.

Joint funding and cooperative research is of huge value, not only between the UK and US, but also with other international partners, including developing countries. The SBLC encourage the funding agencies to respond accordingly. Interest in synthetic biology is growing with over 40 countries currently engaged in related activities. In particular, countries are encouraged to share best practise, governance, responsible innovation practices, metrology and standards, providing that such standards assist open source access and sharing resources, rather than stifle innovation.

Action 6-12: Amanda Collis to discuss (i) the potential for synthetic biology to provide solutions for natural and man-made threats and (ii) workshops to support policy discussions with the cross-council synthetic biology working group.

Dr Rowan McKibbin (RCUK) explained that this would form a discussion item at the next cross-council working group, expected to take place at the end of January 2015. The cross-council working group has representatives from five research councils (BBSRC, EPSRC, ESRC, MRC and NERC), Innovate UK, DSTL and SynBio SIG.

Action 7-8: Dr Rowan McKibbin or Dr Amanda Collis to provide an update on the discussions of the cross-council working group at the next SBLC meeting (see action 6-12).

Action 6-13: SynBio SIG to analyse company membership of the SynBio SIG, including sectors and where they fit in the supply chain.

Dr James Brown stated that of the 909 members of the SynBio SIG, 253 are from industry, and a further 123 are unclassified. Splitting the data into sectors and along the supply chain will be done manually early in 2015.

Action 7-9: SynBio SIG team to share sector and supply chain data of SynBio SIG industry membership with the SBLC, either by email or at the next SBLC meeting.

85-90% of the SynBio SIG membership has opted-in to receive the regular SynBio SIG e-newsletter. The SynBio SIG team also interact with additional individuals in the synthetic biology field that are not members of the SynBio SIG. The SynBio SIG team regularly shares non-confidential data with related communities, including but not limited to SynbiCITE and the Rainbow Seed Fund managers. The synthetic biology community is encouraged to use the SynBio SIG distribution channels to disseminate news effectively.

The observers were invited to raise any questions: none were forthcoming.

3 Introduction

Prof Lionel Clarke gave a second introduction for the benefit of those observers who arrived after item 1. Lionel thanked the observers and presenters for attending, particularly acknowledging the delegation from France.

4 Research Centre Updates

Updates were provided from Prof Richard Kitney (SynbiCITE and CSynBI), Dr Alan Burbidge (Nottingham SBRC), Dr Paul Race (BrisSynBio), and Dr Jim Haseloff (OpenPlant). The floor was opened for questions and comments.

What is the level of coordination between the centres? Is it managed by BBSRC?

Dr Rowan McKibbin stated that now the centres have been established, efforts are being made to facilitate coordination and networking. Three additional synthetic biology research centres will be announced shortly, and they will all be encouraged to network with each other and with other centres of excellence. The SBLC has also established an informal science and technology sub-group to bring together the research and commercialisation activities of these centres and to provide a direct link to the SBLC.

Emotions are a fundamental human condition and should be part of the synthetic biology discussion. The audience here today does not reflect all stakeholders that could be here.

Prof Lionel Clarke acknowledged that discussions with wider stakeholder groups are an important and valuable part of SBLC activity. It was noted that responsible research and innovation was reflected in the presentations of each of the synthetic biology research centres, but we need further clarification on what RRI means to different groups. The community would benefit from worked examples of stakeholder engagement.

Prof François Képeès (GIP Genopole) presented the story of GIP Genopole.

5 Regulation & Engagement

Prof Joyce Tait, Prof Richard Kitney, Dr Tim Fell and Sir Roland Jackson provided an update on behalf of the SBLC governance sub-group.

The governance sub-group has a diverse membership with two positions pending (as discussed under item 2, action 6-8), which should be resolved shortly. The terms of reference and minutes of previous meetings are available on the SBLC website.

The governance sub-group has met on three occasions to date. The first meeting focused on establishing the terms of reference and agreeing the mechanisms of how the sub-group would operate. The sub-group advises the SBLC in both a pro-active and responsive manner. All outputs of the sub-group must be approved by the SBLC.

Responsible research and innovation (RRI) is a frequent discussion topic for the governance sub-group. Innovate UK proposed the development of a RRI standard in collaboration with BSI, which the sub-group considered an excellent, useful mechanism to disseminate the response of businesses to responsible innovation (not just the response of academics to responsible research, which is covered by the research councils). The subgroup is disappointed that discussions have not continued.

The membership of the governance sub-group includes Michael Paton (HSE), who has provided updates on the ongoing two-year consultation period regarding the GMO contained use guidelines. It is likely that some parts of the current regulation will be removed as they are no longer required or defensible.

The governance sub-group has provided a series of responses and contributions regarding the UN CBD Cartagena Protocol and the implementation of the Nagoya Protocol. The contributions of the governance sub-group have influenced the discussions that are taking place. Such inputs are leading to more collaborative approaches that allow the SBLC and governance sub-group to make effective contributions in a timely manner.

There is a recognised need for more public dialogue around synthetic biology. However, this is not something the SBLC or governance sub-group should do in isolation, rather the SBLC should contribute to the activities of other bodies. Public dialogues have already been carried out at the early research stage. Future public dialogues should focus on actual products and processes as examples of a specific technology development.

The governance sub-group was initially surprised to see at least two NGOs object to the relationship between Ecover (detergent manufacturers) and Solazyme (that uses synthetic biology to produce algal oil in place of palm oil). The reaction of these companies is seen as an example of how companies should react to such objections.

Discussions of the governance sub-group have, to date, focussed on applications in green and white biotechnology, at least in part due to the focus of the CBD. Future meetings are likely to explore red biotechnology and health-related issues, such as the development of diagnostic tools and new drugs.

The floor was opened for questions and comments.

The three SBRCs talked about responsible research and innovation and the SBLC wants to be involved in public dialogues. Can we and should we wait for someone else to do them?

Public dialogues focussing on research (not innovation) have already taken place. They have influenced activity and their messages are still live. However, as the field moves towards a range of potential applications, the debate is likely to change. It will be important not to consider synthetic biology as a single process, but to consider it in the context of how it can contribute to potential solutions to grand socio-economic challenges. The synthetic biology community must look outward with humility and commitment. It is possible to have positive debates and discussions in the context of other technology solutions. There will be areas in which synthetic biology can contribute, and areas it cannot. Currently, only interested stakeholders are taking part, not the wider public. It is important for research, innovation and societal communities to understand one another better, hence a specific public dialogue activity may be required. However, synthetic biology should not be stigmatised: RRI is applicable to all research and innovation, not just synthetic biology, and many issues addressed are common to a wide range of emerging technologies. A broad standard for RRI, as previously considered by Innovate UK in collaboration with BSI, could help reduce or avoid such misperceptions of synthetic biology.

It should be noted that, since 2006, the international synthetic biology community has emphasised societal, ethical and environmental issues. This proactive (not reactive) approach ensures such factors are considered at the beginning and throughout the synthetic biology design cycle. iGEM, as a specific example, holds up aspiring role models for the next generation of synthetic biologists, and iGEM participants intrinsically believe in RRI and the power for synthetic biology to tackle environmental and societal issues. The synthetic biology community has grown considerably through the past decade, drawing upon a broad diversity of technological and cultural backgrounds, and informed by unprecedented global networking and learning opportunities. Such an operating environment would appear to be effectively stimulating awareness of RRI and helping to embed its principles within the community.

The GM crop debate in the 1990s was highly focussed around a specific concept, involving coordinated NGOs and a united press campaign. Synthetic biology by contrast spans a broad range of underlying capabilities, applicable to a wide and expanding range of useful outputs, hence the stakeholder demographic is much broader. Applications of the technology are as diverse as the socio-economic challenges. The governance sub-group noted that dialogues need not produce binary yes/no answers: the situation is clearly more nuanced, and would be better progressed in the context of a range of specific exemplar products.

How can RRI be embedded in the synthetic biology community?

We are on the verge of some game-changing advances in the way in which we interact with our environment. The principles of responsible innovation are the same, regardless of the technology area. For example, the airline industry has a culture of early warnings, and people in the industry are prepared to look ahead and speak up. Such an approach should be adopted across all technology areas, including but not limited to synthetic biology.

The SBLC has today stated that the synthetic biology community is proactive, and that iGEM participants are idealistic and proactive. However, at every synthetic biology meeting this is only interpreted as the public are fearful and irrational. This framing is a problem.

Dialogues require trust, and trust is a two-way process, in this case between the synthetic biology community of scientists and industrialists and the wider public. From the comment it appears that scientists and industrialists don't trust the dialogue process, which may come from the personal negative experiences of those that have engaged with NGOs. The generational gap between iGEM participants (usually graduate students, post-graduates and post-doctorate research associates) and their mentors is huge: iGEM participants are naïve but hopeful, whereas their mentors are often scarred and defensive.

The next generation of synthetic biologists come from a variety of backgrounds, including policy and strategy. Their primary motivations are rarely financial, but changing the world, and their efforts should be supported. Dialogues often focus on hypothetical arguments and generalisations, but examples of synthetic biology in practise are beginning to enter our everyday lives. Dialogues should emphasise the impact synthetic biology can have on grand challenges and developing countries, not just focus on the technology. It is important to conduct dialogues in an appropriate way.

For clarification, the SBLC encourages an active dialogue. Experts from a variety of fields should be involved, even if they don't agree that synthetic biology is the way forward. RRI is at the heart of synthetic biology. UK Government and the World Economic Forum see synthetic biology as a major generator of wealth and industry. RRI and synthetic biology can together deliver a major economic advantage for the UK, Western Europe and beyond.

In France, synthetic biology projects include sociologists and philosophers. The aim is not perfect acceptance, but consideration of the wider factors.

The SBLC agreed that consensus is not the intended outcome of a dialogue.

Can the creative industries be included? This technology could impact upon everyday things, from shoes to beehives. Creative individuals might find surprising uses for these genius inventions.

Several synthetic biology projects have involved artists, often resulting in fun, stimulating and interesting outcomes, some of which have been useful.

Prof Lionel Clarke thanked the participants for engaging in the discussion.

6 Education & Training

The International Genetically Engineered Machine competition (iGEM), established in 2003, is an annual competition that runs for 12 weeks each summer. Undergraduate teams work on a project, submit it to the competition and attend the jamboree in Boston. iGEM is an incredibly important educational tool for synthetic biology: the competition produces many high quality students that go on to study PhDs, and many US synthetic biology start-ups and spin-outs originate in iGEM projects. Prof Rickard Kitney observes the iGEM board.

Many of the UK teams were successful in the 2014 competition. The iGEM team from Imperial College London, runners-up in the 2014 competition for undergraduates, delivered a group

presentation on their project 'Aqualose'. The team engineered bacterial strains to produce functionalised, robust cellulose materials at very low cost, which can be used to remove contaminants from water.

The floor was opened for questions and comments.

Congratulations on this major achievement! This looks like a useful project. What next?

The team members have returned to their studies, although they would like to publish their work and take it forward once they graduate. They have the support of their supervisors at Imperial College London.

Has the iGEM experience influenced where you would like to be in five years?

Many of the team members would like to embark upon PhD studies. One member of the team has already embarked upon a PhD outside of synthetic biology, but they would like to return to synthetic biology in the future. Others would like to explore internships, working for small biotechnology companies or start-ups. The competition clearly instils a 'can-do' attitude in the participants.

I am impressed with your passion. Have you considered how best to protect your intellectual property? It could be quite valuable.

The rules of the iGEM competition state the outputs must be open source. However, the supervisors at Imperial College London are experienced in managing intellectual property. The project has produced a platform technology available to anyone. However, specific applications can be protected.

Congratulations! This is absolutely fantastic. The implications of your invention and the potential applications are significant: it could solve very real problems that affect millions of people around the world. Please find a way of passing these practical applications on, even if you don't want to do it yourselves. Synthetic biology is penetrating societal consciousness, but often in a confused, uncertain, doubtful way. This is a practical application that could be discussed and used in a public dialogue. This project could increase public understanding and solve problems.

No response was made to this comment.

What were the things that surprised you along the way?

The team was overwhelmed by how attached each member became to the project: all ten team members worked incredibly hard investing many personal hours, and faculty members are equally enthusiastic. Looking back, it's amazing to see how much work they did in a relatively short period. The team was driven by the knowledge that the project has the potential to solve a real world problem.

Each iGEM project must consider policy, practise and public perception. The team chose to focus on a real world problem that could be solved with synthetic biology, rather than simply trying to ease people's minds about the technology in isolation. The first three weeks of the twelve-week project were spent brainstorming the space and shaping the project.

What course are you on?

Courses include biology, biochemistry, biotechnology and bioengineering.

The contributions from the research councils, which have supported both this and previous years teams, was gratefully acknowledged, not just for Imperial College London but also for the whole UK community that has participated.

It was recognised that the Imperial College team was just one of numerous iGEM teams that continue to successfully represent the vibrancy of the UK-wide Synthetic Biology student community and their supportive academic tutors, year on year. Opportunities to recognise and build upon this activity should be seriously considered, as a vital resource for the future development of the sector.

7 Ministerial Remarks

Prof Lionel Clarke introduced George Freeman MP, Parliamentary Undersecretary of State for Life Sciences at the Department for Business, Innovation and Skills and the Department of Health.

George Freeman firstly paid tribute to David Willetts MP: George Freeman has picked up half of his remit, and it is very telling that it takes two to fill David Willett's shoes George Freeman is the first (and hopefully not the last!) Minister for Life Sciences.

As Britain looks to build its way out of debt, we must consider genuinely sustainable models for growth and contribute towards extraordinary growth around the UK. There is a need to build on proprietary information generated in universities and the wider academic research cluster, and it is important that the public and private funding landscape is joined up. Industrial biotechnology and synthetic biology are technologies that underpin the application of biosciences to the bioeconomy, including but not limited to food, medicine and energy. The appliance of bioscience will help catalyse extraordinary breakthroughs for mankind. Over the next 30 years, underdeveloped countries will go through the industrialisation that we have already experienced. We must help such countries go through such revolutions more quickly. We can also apply science to new processes, technologies, products and markets. Britain must be a crucible for new technologies and new companies supporting both export and inward investment.

George Freeman expressed delight that synthetic biology is one of the 'Eight Great Technologies'. Such prominence and focus allows the UK to play a leading role in this international field. The minister was pleased to see the French delegation at the meeting, and is interested in hearing more about the recent UK-US policy meeting and trade mission.

The minister was excited to hear about the activities of the SynBio SIG, with support from the Department for Business, Innovation and Skills. The minister was thrilled to meet the iGEM team from Imperial College London: their success speaks volumes about the extraordinary talent we have in our universities and the next generation of scientists.

The minister's role in Government is to speak for the life sciences in the media and the House of Commons, and to fund the deep science and the translational work to later be pulled into industry. The work of the SBLC, which plays a key role in leading this field from the top, is crucial to such

translation and to cultivate the next generation of leaders. Enquiring minds drive new opportunities, and leadership groups need more young minds and young leaders.

George Freeman noted that few things elicit greater distrust than big science, big data, big Government, big business, and big society. The UK still carries £1 trillion debt, hence we must defend every pound of public money we spend: we do not have a divine right for funding. The minister encouraged the synthetic biology community to tell their stories and take every opportunity to promote what they are doing. Real world problems should inspire us to explore how synthetic biology can solve the lack of basics of life.

The minister would like to see a copy of the existing roadmap and the planned next steps. The minister recognises the importance of a secure funding landscape, and he intends to build a cross-party consensus and unpartisan support for synthetic biology. The minister is very much a policy lead and politician in support of this great field of venture and enquiry and he looks forward to celebrating the success of the life sciences in the future.

8 The UK Synthetic Biology Ecosystem

Prof Lionel Clarke summarised the meeting for the minister.

The UK roadmap for synthetic biology does not suggest what science should be done, but what framework and environment are required to allow the science to flourish and be translated within the UK. The roadmap has, for example, resulted in:

- significant investments, such as the three existing synthetic biology research centres, with a further three to be announced shortly, providing a strong infrastructure for academic that links with industry;
- the acceleration of technology moving responsibly to market, via SynbiCITE and investments from Innovate UK and the Rainbow Seed Fund;
- the formation of the synthetic biology special interest group, which supports a community of more than 900 members, and provides a direct link to the SBLC;
- the UK playing a leading role internationally to drive synthetic biology forward, through engagements at the scientific level (such as ERASynBio), meetings with the Six Academies, input into the US NAS roadmap for synthetic biology, instigating a UK-US policy meeting, Franco-British meetings and UKTI trade missions;
- and the formation of the SBLC.

The SBLC, an independent group of stakeholders from different institutions, has impact by considering:

- regulations, both within the UK and internationally;
- the breadth of stakeholders and how best to ensure engagement;
- what intellectual property management practices protect investments and stimulate innovation;
- overall approaches to strategy and protocol;
- and how to develop an effective synthetic biology ecosystem in the UK (including a proposal to the recent capital investment consultation).

The SBLC will shortly instigate a process to take stock of progress to review and update the roadmap implementation plans ('phase 2') to ensure the UK synthetic biology ecosystem is as vibrant as possible.

9 International Activity

Prof Tim Dafforn (academic at the University of Birmingham, founder of Linear Diagnostics, and Entrepreneur in Residence at the Department for Business, Innovation & Skills) summarised the recent trade mission to San Francisco, jointly organised by UKTI, BIA and SynBio SIG. Twenty UK companies participated in a series of visits to see how companies in the Bay Area operate, and to deliver pitches at the SynBioBeta conference. Both the US and UK companies that participated were impressive. Interestingly, the US conference delegates were noticeably younger than those from the UK.

The focus of business activity in the US is in the provision of services, such as *in silico* services, DNA synthesis/assembly, production and scale-up. For example, Twist Biosciences aims to produce 10,000 genes on a single chip for \$1,000. Relatively few of the US companies deliver products, and the products offered by the UK companies showed more variety.

Differences in business models and the availability of finance means that US entrepreneurs ask for (and receive) large sums of money to transform industry, whereas UK entrepreneurs ask for significantly less. The US has also moved towards procurement innovation: government procurement is used to generate contracts that help newly established companies.

The UK interaction with the US has been particularly productive, and the UK should continue to work with colleagues in the US and to align as much as possible, noting differences and the reasons for them.

Eric Guittet (Directorate General for Research and Innovation) summarised the French synthetic biology strategy.

In 2009, a French Government initiative entitled 'Investments for the Future' committed €520 M for health and biotechnology, which included synthetic biology and computational biology. The Strategie Nationale de Recherche more recently held 10 workshops to consider 14 societal challenges, including health and wellbeing. These workshops identified 38 prioritised orientations, which have since been narrowed down to a preliminary list of 14 specific actions.

An advisory board will bring together a diverse range of stakeholders to develop a national plan for systems biology, which, in France, includes synthetic biology.

James Brown (Knowledge Transfer Network and Synthetic Biology Special Interest Group) delivered a brief presentation on the synthetic biology Leadership Excellence Accelerator Program, LEAP.

Leading biotechnology requires the coordination of people and activities, not just on a national or European level, but also in a global context. Synthetic biology and wider biotechnology need leaders that can talk about the socio-economic concerns as well as the technical aspects of the field.

LEAP, which ran for the first time in 2012, is a programme that gives participants the time and space to consider aspects outside their own techniques. In 2012, 20 fellows participated and devised 13 action plans, which were later written up and are summarised in the 2012 annual report. One example, announced at SynBioBeta in San Francisco in November 2014, is a series of international workshops to consider international standards.

Yearlong international LEAP fellowship programmes are planned for the US in 2015, the UK & Europe in 2016, and in Asia in 2017. The 2015 programme includes a landscaping trip to Washington DC in February 2015 and a second workshop in June 2015. Participants will be encouraged to engage with fellows from the 2012 programme. Catalyst funds will be awarded to get action plans up and running. Mentors and industry funders are currently being recruited.

Questions were welcomed from the floor.

Please can you elaborate on the interaction between the SBLC and NGOs?

Interaction with NGOs is primarily directed through the SBLC governance sub-group. The sub-group is developing a mechanism to work with NGOs as part of a broader stakeholder community, and talk through worked examples of synthetic biology activity.

There is a need to bring the public with you on your synthetic biology journey, which is a challenge. Others have used science fiction: 'Star Trek' inspired the mobile phone, and 'Blade Runner' features organic devices. Can we inspire filmmakers to consider synthetic biology?

Messages in the standard media play an important role. The SBLC does not desire to push a particular view, but should demonstrate that synthetic biology is a responsible and trustworthy discipline. Tim Dafforn has been on a programme with Stephen Hawking. Synthetic biology is already capturing the imagination of the creative industries: for example, Daisy Ginsberg is a designer, artist and writer with a keen interest in synthetic biology, and the second BIO-FICTION Science Art Film Festival took place in Vienna in October 2014. An observer commented that effective messaging should start with the problem rather than the solution, which then makes synthetic biology the subtext.

The iGEM project changed when the team members spoke to those providing infrastructure. More people need to engage with end-users to determine what might be the right solution (although scientists must understandably push their technology to obtain funding).

Participants in the synthetic biology Lean Launchpad program, starting at SynbiCITE in January 2015, required participants to engage with potential customers to revise their business plan over an intensive ten-week period.

10 Commercialization & Community

Tim Dafforn chaired this session, which focussed on outputs and impacts of synthetic biology.

Chris Jones (Innovate UK) gave an update on the outputs arising from Innovate UK investments in synthetic biology (in response to action 6-14). Upon completion of a project, grant-holders are asked

about their exploitation plan. Only two of twenty-one projects have completed so far, so formal analysis will take place later in the year.

Action 7-10: Chris Jones to provide an update on the outputs arising from Innovate UK funding in a future SBLC meeting.

Innovate UK invests approximately £400M per year in innovation. We've already heard that the UK has the capability and capacity for synthetic biology. However, there are differences between the research base and commercial landscape: synthetic biology is very broad, and the research base is much more likely to self-identify than industry.

Innovate UK runs competitions to fund innovation. Two competitions specific to synthetic biology have funded 21 projects, although synthetic biology projects have also been funded through other competitions. In total, 138 collaborative projects have involved 67 companies (24 micro, 26 small, 7 medium and 10 large companies). All projects are collaborative, either with the research base or other industry.

To date, Chris has visited 30 companies actively undertaking synthetic biology. The UK synthetic biology industry is currently focussed on tools and services that drive turnover, rather than investment to build IP. As such, there are few, large, highly capitalised and highly visible synthetic biology companies, and a distinct lack of medium-sized companies. This contrasts with other, well-financed overseas competition. However, collaboration is highly effective. Moving ahead, we must continue to incentivise engagement between industry and the UK knowledge base, and to provide access to funding and finance: funding from the research councils, Innovate UK, the Rainbow Seed Fund and others must be aligned. In 2015, synthetic biology will be in scope of a competition entitled 'integrated omics.' We must continue to train and retain those with the appropriate skills. Industry needs to react to disruptive changes in the supply chain, and the data and software sectors must be creative to develop sustainable business models.

Tim Fell provided some personal reflections on behalf of Synthace and the BIA, which has a group of 14 companies with an interest in synthetic biology.

The UK was one of the first out of the blocks coordinating different synthetic biology stakeholders to provide vision, leadership and resources. However, others are catching up fast with a better track record of commercialisation. The UK must now capitalise on the existing infrastructure and move commercialisation up the agenda in 'phase 2' of the implementation of the UK synthetic biology roadmap.

Innovate UK funding is great for start-ups: it provides funding, and the competitive nature implies due diligence, which can be beneficial with early seed stage financing. However, applicants should be reminded to stick to projects that are at the core business of a company, and to work on projects that make products you can sell (not that win grants). In balance, Innovate UK funding has pump-primed the UK synthetic biology industry.

Venture capitalists don't yet fully understand synthetic biology, and most don't think they have the necessary expertise to assess it. Instead, companies must pitch a more standard biotechnology idea, rather than branding it as synthetic biology. The Rainbow Seed Fund is capped at £500,000, which isn't going to bridge the gap between series A and series B funding. A larger fund would be more beneficial. The UK should consider the Government procurement programmes available in other countries, which facilitate contracts for homegrown companies to supply products.

James Brown gave a brief update on the activities of the Synthetic Biology Special Interest Group (SynBio SIG), which focuses on industry and commercialisation. SynBio SIG staff work in close collaboration with those at SynbiCITE. The SynBio SIG works with the UK synthetic biology community beyond the 900 members signed up to the online community. The aim is to learn about the companies and technologies to build collaborations, not only within the sector but also in other potential markets: a workshop entitled 'Biosensors for Bioprocesses' is scheduled for 16th December 2014, and future events in other sectors will follow on 2015. The SynBio SIG provides secretariat to the SBLC and support in the implementation of the UK roadmap for synthetic biology. International activities include: attending Synberc retreats to meet US companies and encourage them to come to the UK; LEAP; working with UKTI and the BIA to deliver a UK mission to the Bay Area; bringing SynBioBeta to London; and supporting UK participation in iGEM.

Further questions and comments were invited.

Can you expand on why good grants don't always mean good products?

Tim Fell explained that the requirement to collaborate could result in projects that are outside a company's core business. There is a formula to writing successful grant proposals, and projects that make money in the short-term don't always warrant public funding. The UK is a fantastic place to establish a company: the research base generates fantastic ideas, Innovate UK provides funding to de-risk early-stage innovation, SynbiCITE can provide additional support, there are tax breaks on personal investments, and there is a strong angel investor community. However, growing a company is still a challenge.

Professor Richard Kitney explained that many teams use iGEM to test new ideas and embryonic projects. For example, four of the seven iGEM teams arising from Imperial are on a pathway to commercialisation. Dr James Brown suggested more could be done to make the route to commercialisation easier. Options include competitive follow-on funding to further support iGEM projects. It is noted that very few postgrads and postdocs in the UK come forward to set up companies, but more take the opportunity in the US.

Professor Joyce Tait explained that expensive and time-consuming regulatory systems create an environment where small companies have to exit through a collaboration with, or by selling to a multi-national company, hence the lack of medium-sized companies in the field. This also leads to a preponderance of incremental innovation and a relative lack of disruptive, path-breaking innovative technologies. The pharmaceutical sector is now changing to make the regulatory system cheaper and faster to negotiate in some sectors and we need to address the regulatory system to better support synthetic biology-related industries while continuing to ensure safety to people and the environment.

11 Closing remarks

Lionel Clarke thanked everyone for their contributions, including the organisers, SBLC members, chairs, presenters and observers, and announced that the next open meeting is likely to fall in Summer 2015. Participants were encouraged to complete feedback forms before leaving.

SBLC Secretariat, February 2015

Annex 1 Actions arising from the 6th meeting of the Synthetic Biology Leadership Council on 3rd July 2014

Action 6-1: Lionel Clarke to write a note of thanks to Carol Boyer-Spooner, Sharmila Nebhrajani and Chris Warkup.

Action 6-2: Amy Tayler to seek permission from those named in paper 2 (feedback from the open meeting) before publishing on the SBLC website.

Action 6-3: Helen Bodmer and Shami Ahmed to consult Sharon Ellis before asking Julian Jackson (Defra) to (i) share Defra's response with the SBLC (ii) have another telecon with any interested members of the SBLC.

Action 6-4: Dick Kitney and the science and technology sub-group to consider the EU consultation regarding the definition of synthetic biology.

Action 6-5: Amy Tayler to share Ben Sheridan's revised digital bio-manufacturing strategy with the SBLC.

Action 6-6: James Brown to finalise a logo for UK synthetic biology activities and provide guidelines for use.

Action 6-7: Dick Kitney, David Tew, Janet Thornton, Amanda Collis and Joyce Tait to consider how synthetic biology might be applied to a grand challenge, for presentation at the next SBLC meeting.

Action 6-8: Lionel Clarke to invite the selected nominees to join the SBLC governance sub-group.

Action 6-9: Secretariat (KTN and BIS) and relevant UK Government Departments to look out for future UK, EU, UN and OECD consultations (which often come through a Government department) and to seek opportunities for the SBLC to be engaged at an earlier stage wherever possible and appropriate.

Action 6-10: Shami Ahmed to check the deadline for responses to the pro-regulation innovation framework, and Joyce Tait to coordinate a joint response on behalf of the SBLC governance subgroup.

Action 6-11: Dick Kitney, Amanda Collis and Joyce Tait to summarise current activities concerning biosecurity for use at a policy meeting in October 2014.

Action 6-12: Amanda Collis to discuss (i) the potential for synthetic biology to provide solutions for natural and man-made threats and (ii) workshops to support policy discussions with the cross-council synthetic biology working group.

Action 6-13: SynBio SIG to analyse company membership of the SynBio SIG, including sectors and

where they fit in the supply chain.

Action 6-14: Chris Jones to consider the outputs of TSB investments in synthetic biology.

Action 6-15: Lionel Clarke to invite Tim Dafforn to join the SBLC.

Action 6-16: Secretariat to invite a representative from the business bank to attend a future meeting of this council.

Action 6-17: BIS secretariat to share an update on the BIS/Defra discussions regarding the proposed implementation of the Nagoya Protocol with the SBLC.

Action 6-18: Joyce Tait and Lionel Clarke to plan (i) who should engage in a discussion of policy and evidence vs. politics and public perception, (ii) whether the SBLC, SBLC governance sub-group or other organisation should lead the activity and (iii) whether to invite Defra to participate in a telecon with the SBLC or attend a future meeting of the SBLC.

SBLC Secretariat, August 2014

Annex 2 Actions arising from the 7th meeting of the Synthetic Biology Leadership Council on 27th November 2015.

Action 7-1: Prof Richard Kitney to direct the science and technology sub-group in preparing a paper regarding the definitions of synthetic biology for the next SBLC meeting.

Action 7-2: Dr James Brown to make branding UK synthetic biology branding available with guidance for use.

Action 7-3: Dr James Brown and Prof Lionel Clarke to collate views from the consultation in time for the next SBLC meeting.

Action 7-4: Prof Lionel Clarke and Prof Joyce Tait to fill the outstanding positions on the SBLC governance sub-group and to report back at the next SBLC meeting.

Action 7-5: All SBLC members, observers and secretariat to send consultation and calls for responses to the SBLC co-chair (Prof Lionel Clarke), the Governance Subgroup Chair (Prof Joyce Tait), and the SBLC secretariat (Dr James Brown and Dr Amy Tayler) in a timely manner.

Action 7-6: On occasions when the SBLC is unable to respond to a consultation, SBLC Secretariat to reply stating that the lead-time is insufficient.

Action 7-7: SBLC members to provide feedback on draft report of the UK-US policy meeting to Prof Lionel Clarke in the coming fortnight.

Action 7-8: Dr Rowan McKibbin or Dr Amanda Collis to provide an update on the discussions of the cross-council working group at the next SBLC meeting (see action 6-12).

Action 7-9: SynBio SIG team to share sector and supply chain data of SynBio SIG industry membership with the SBLC, either by email or at the next SBLC meeting.

Action 7-10: Chris Jones to provide an update on the outputs arising from Innovate UK funding in a future SBLC meeting.

SBLC Secretariat, February 2015