



Synthetic Biology Leadership Council

Meeting 8, 18th March 2015

Room C11, Department for Business, Innovation & Skills,
1 Victoria Street, Westminster, London SW1H 0ET

Attendees

SBLC Members, observers and secretariat

George Freeman MP	Department for Business, Innovation & Skills, SBLC co-chair
Prof Lionel Clarke	SBLC co-chair
Prof Richard Kitney	Imperial College London
Prof Dale Sanders	John Innes Centre
Prof Joyce Tait	Innogen Institute, University of Edinburgh
Dr David Tew	GSK
Prof Janet Bainbridge	UKTI (UK Trade & Investment)
Dr Amanda Collis	RCUK (Research Councils UK)
Dr Tim Fell	BioIndustries Association (BIA) and Synthace
Prof Tim Dafforn	Department for Business, Innovation & Skills and University of Birmingham
Sue Dunkerton	Knowledge Transfer Network
Tim Higginson	Department for Business, Innovation & Skills
Sarah Cundy	Defra
Dr Amy Tayler	Knowledge Transfer Network and SynBio SIG
Dr James Brown	Knowledge Transfer Network and SynBio SIG
Dr Chris Jones	Innovate UK

Guests

Simon Kendall	Department for Business, Innovation & Skills
Mario Rivero-Huguet	UK Science and Innovation, British Consulate-General, Montreal
Renaldo Battista	Fonds de recherche Québec en santé
Graham Carr	Concordia University
Patrick Covello	National Research Council
Serge Desnoyers	Canadian Institutes of Health Research
Danielle Kemmer	Genome Quebec
Caroline Martin	Canadian High Commission, London
Vincent Martin	Concordia University
Neil McIntosh	Industry Canada
Patrick Philip	Quebec Government Office, London
Donna Viger	National Research Council
Kathrina Yambao	Public Health Agency of Canada
Ken Cooper	British Business Bank
David Hite	Bridge 37

Apologies

Alastair Kent	Genetic Alliance UK
Shamimara Ahmed	Department for Business, Innovation & Skills
Mike Edbury	Government Office for Science

1 Welcome & introductions

Lionel Clarke reminded the SBLC that the Canadian delegation would join the meeting at 10:20 until lunch, and that guests from the British Business Bank and US Investment Company Bridge 37 would help the SBLC with their discussion in the afternoon. As such, additional closed discussion may be required outside this meeting.

2 Internal Business: Minutes & Actions arising from the last meeting***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.***

Richard Kitney directed the SBLC to Paper 2. This informal science and technology subgroup consists of representatives from SynbiCITE, the 7 synthetic biology research centres (SBRCs, based at Imperial College London, University of Bristol, University of Nottingham, University of Cambridge/John Innes Centre, University of Manchester, University of Edinburgh, and University of Warwick) and the two EPSRC centres of doctoral training (at University College London and University of Oxford). This activity complements the more formal networking activities arranged by BBSRC, such as the meeting planned for the 15th – 16th April 2015.

Richard noted that within the group there is a lot of interest and enthusiasm to share information and coordinate activity. A recent meeting was very well attended, with only the University of Edinburgh unable to be there. The meeting enabled the PIs of the new SBRCs to give an overview of activity. Of particular note are: the integration of the SBRCs with industry via SynbiCITE and other routes; Linda Pile (Stanford University) has a fellowship to spend one week a month in Cambridge to explore intellectual property, freedom to operate, and the development of an 'EZ-MTA' to make it easier for both companies and academics to agree the terms of working together; a program for the exchange of DNA parts and protocols; and plans to hold a workshop to share expertise on robotics for the benefit of the foundries. The SBLC reiterated how important it is for industry to be involved in the development of the EZ-MTA. Tim Fell recommended that Keltie be involved, and Joyce Tait volunteered the Innogen Institute.

Action 8-1: Prof Richard Kitney to initiate the involvement of industry (through the SBLC), Keltie and the Innogen Institute in the development of the EZ-MTA.***Action 7-2: Dr James Brown to make branding UK synthetic biology branding available with guidance for use.***

James Brown (SynBio SIG and KTN) explained that image files are available on request through the SynBio SIG. So far, the files have been shared with those organising Synthetic Biology UK 2015, and the coordinators of a directory of synthetic biology companies (UKTI and BIA). Guidelines for use will follow in due course.

Action 8-2: Dr James brown to provide guidelines on use of the UK synthetic biology branding.

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

To be covered under agenda items 5 and 9.

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.

Joyce noted that we have not received responses to the invitation that Lionel issued, and further candidates may need to be considered. To be covered further under agenda items 3.

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

and

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.

Lionel noted that having Defra on the SBLC and HSE on the SBLC governance sub-group is a great asset. The SynBio SIG will also publish a public calendar (expected in June/July), on which consultation deadlines, events and activities can be highlighted.

Action 8-3: All requests for SBLC responses to be sent to (i) SBLC secretariat, (ii) Prof Lionel Clarke and (iii) Prof Joyce Tait.

Action 8-4: SynBio SIG to launch an online calendar of events and activities, and to encourage community members to suggest items to be entered.

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.

Lionel didn't receive any feedback, and the [final report](#) has now been published on the SBLC website. Both biosecurity and standards need consideration as we refresh the UK roadmap for synthetic biology.

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 also action 6-12).

Amanda Collis chairs the cross-council working group, which consists of representatives from EPSRC, ESRC, NERC, MRC, BBSRC and Innovate UK, and which meets every two months. Current activities include: an overview of the 'Synthetic Biology for Growth' programme; planning a formal meeting of the PIs of the seven SBRCs, which will include a discussion on the roadmap refresh; support for the national meeting 'Synthetic Biology UK 2015'; refreshing the UK roadmap for synthetic biology; reviewing upcoming funding calls, including but not limited to 'profiting from biological complexity/integrated 'omics' from Innovate UK, and the lead agency agreement between NSF and RCUK, in which synthetic biology has been highlighted by BBSRC.

With regard to 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), natural and man-made threats will be rolled into the roadmap refresh. BBSRC and DSTL are also discussing how synthetic biology might contribute to detection and monitoring.

The SBLC noted that while the [US synthetic biology approach](#) (is very different to the UK roadmap (the US strategy focuses mainly on the generation of pathways from feedstocks to chemicals), there are also areas of alignment.

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.

James Brown explained that this analysis has been conducted as part of the refresh of the UK synthetic biology roadmap. A directory of UK synthetic biology companies is to be launched by UKTI, the BIA and SynBio SIG in June/July 2015. The open meeting or national meeting (Synthetic Biology UK 2015) would be good opportunities to share these data.

Action 8-5: Innovate UK, SynbiCITE and the SynBio SIG to meet quarterly to share industry contacts.

Action 8-6: Dr Amy Tayler to circulate the upcoming SBLC meeting dates: on 2nd July an extraordinary closed meeting of the SBLC to focus on the roadmap refresh; on 16th July an open SBLC meeting; on 22nd October a closed SBLC meeting.

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

To be covered briefly under agenda item 7, although only five of the Innovate UK synthetic biology projects have finished thus far. Five more projects are scheduled to complete in a few weeks, hence this will be covered in more detail at a later SBLC meeting with an associated paper, which will no doubt contribute to the refresh of the roadmap.

Action 8-7: Dr Chris Jones to provide a paper and update on completed Innovate UK synthetic biology projects at a future meeting of the SBLC.

The SBLC agreed the minutes of SBLC7.

Action 8-8: Dr Amy Tayler to publish the agreed minutes of SBLC7 on the SBLC website.

Lionel provided the SBLC with an update on progress with plans for the refresh of the UK roadmap for synthetic biology. The SBLC agreed that the term 'roadmap refresh' is suitable and manages expectations, and agrees that the refreshed roadmap should determine how to generate maximum value from synthetic biology excellence and investment within the UK and retain it within these shores.

The development of the existing UK roadmap for synthetic biology was carried out relatively quickly and the SBLC agreed that agility is still key. We've learned much by doing, but the SBLC agreed it wouldn't have done anything radically different even had more time been dedicated to the process. Indeed, contacts in the IIS and elsewhere have fed back that the UK roadmap is looked upon favorably. We've already had

large-scale public investment and policy support for synthetic biology (eg: the inclusion of synthetic biology as one of the eight great technologies). The SBLC commented that the refresh should consider: interest from the finance community; communication regarding synthetic biology; plus industrial interest, support and activity.

Although the formal refresh of the roadmap will be published in September, a compelling outline must be submitted to BIS in April in advance of the comprehensive spending review (CSR). Two meetings have been held thus far (in Edinburgh on 3rd March 2015 and in London on 5th March 2015) to garner initial thoughts from the community and help Lionel develop the outline submission for BIS. Lionel summarised the following emerging themes:

- Moving from 'technology push' to 'market pull' and onward to an integrated strategy with greater industrial engagement and more rigorous business analysis;
- Building on invested research platforms;
- A strategic plan to accelerate translation, including better alignment between funding agencies and investment schemes;
- Stimulating commercialisation by improving the risk profile for investors;
- An active plan for public engagement linked to emerging output goals;
- Stimulating innovation through inspirational grand challenges;
- International engagement focusing on standards, governance and partnerships.

Additional community consultations will allow the opportunity for additional contributions between May and September 2015. BBSRC is producing a stakeholder landscape, which should feed into this activity.

The SBLC gave consideration to a 'big ticket' idea that could be delivered with substantial Government support (such as the distributed capital equipment challenge fund that was submitted under the capital consultation at a proposed cost of £20M a year for 5 years). The Research Councils and Innovate UK were advised to keep proposals up to date should the opportunity arise for their consideration by Government.

The SBLC agreed that market pull (rather than technology push) should be front and centre in the roadmap refresh, as should the importance of timeliness, to avoid losing out competitively on the international stage. However, some members of the SBLC raised concerns regarding the risk of disclosing a national strategy to foreign competitors.

The SBLC noted that public engagement is important, but that it should not be in the driving seat. Instead, we should have an active plan for understanding stakeholder perspectives. Further important questions were proposed: *Are we on track? Where will value be generated?* The SBLC considered that 'quick wins' may dissipate elsewhere in the world, but that value for the UK could be created and captured especially by those providing the means to understand complexity.

SBLC members also volunteered the following areas for consideration under the roadmap refresh:

- How might the SBLC engage with the funders?
- How will you facilitate broad stakeholder consultation over the entire period of the project?

- Before Christmas 2014 there were discussions about a Government non-departmental public body (NDPB group). What progress has been made?

The roadmap refresh will be picked up further at the proposed extraordinary meeting of the SBLC on 2nd July.

11 Any Other Business

Lionel invited the SBLC members to raised AOB ahead of the arrival of invited guests.

Amanda Collis raised SBLC membership, and asked whether there is a need to evolve a clear appointments process involving nomination, fixed-term service, and resignation. Amanda also suggested that the SBLC should hold a register of members' interests to protect council members. The SBLC sees benefit in consistency with other sector bodies and leadership councils, for example in terms of the interfaces with the different research councils, terms of reference, and membership. SBLC membership has evolved over the last two years, with the inclusion of representatives from the SBRCs, SMEs and regulators. The approach thus far has been pragmatic and it is important to balance agility and bureaucracy. Lionel presented a diagram that illustrates the underlying structure of SBLC representation and composition of membership, which was well received.

The SBLC values the independence from but partnership with the different funders and stakeholders, and is grateful for public sector support to enable this activity. Offline discussions are ongoing regarding future funding and support for the SBLC and this will be revisited at the next meeting in July 2015. The time that SBLC members effectively volunteer is hugely appreciated.

Action 8-9: SBLC membership and proposed register of members' interests to be added to the meeting agenda for 2nd July 2015.

At this point many of the invited guests were welcomed to the meeting.

3 Governance sub-group update

Joyce Tait directed the SBLC members and invited guests to papers 3 and 4. The governance sub-group last met on 10th March 2015. A large proportion of the meeting was dedicated to the Convention on Biological Diversity and the Nagoya protocol. It was noted that many of the issues raised at the meeting in Korea in October 2014 resulted in no agreement, so there is still much to be considered in the recently launched two-year consultation period. A moratorium on synthetic biology research would be the worst possible outcome. The most constructive outcome would be the conclusion that no additional regulation is required.

Sarah Cundy (Defra) described the different processes feeding in to the convention on biological diversity: an online forum, for which anyone can register and participate (although individuals must be nominated by the head of their organisation); and the formation of an *Ad Hoc* Technical Expert Group (AHTEG), for which nominations must be received by 30th March 2015. Each Party and relevant organisations can prepare individual submissions, which feed into the scientific advisory body to the convention on biological diversity. As such, Defra is also participating separately from the online forum, with a deadline of 30th April

2015. The AHTEG will meet later this year (in September 2015), which will develop a document for further consideration in 2016.

The SBLC governance sub-group will take on the role of contributing to the process. Mike Paton (HSE) has been nominated to the AHTEG on behalf of the UK. However, others are also encouraged to contribute directly to the online forum or to register as an observer to the AHTEG. The decision about the composition of the AHTEG is likely to be taken in July 2015. Lionel noted the importance of submissions to the online forum for those wishing to be considered observers to the AHTEG. Sarah Cundy (Defra) noted that many of the people on the AHTEG are experts in regulation and policy, and that the AHTEG would benefit from a wider membership of genuine technical experts with practical experience.

Action 8-10: SBLC members to consider registering for the online portal and/or membership/observation of the AHTEG.

The SBLC governance sub-group also featured a presentation from Alastair Kent (Genetic Alliance UK) on synthetic biology applications in medicinal products, which also touched on regulation. This will be picked up at a subsequent SBLC meeting.

Action 8-11: Alastair Kent or Joyce Tait to raise synthetic biology applications in medicinal products and the associated regulation at a subsequent SBLC meeting.

4 Cyber-security and Bio-security

Simon Kendall (BIS) is looking at the UK industrial strategy to map risks against the potential contribution (or impact) on the UK economy. Simon gave a short presentation highlighting who might be interested in accessing synthetic biology data, why they might do so, and how the UK synthetic biology community might protect itself.

Should protesters and hacker groups access data, they will likely publicise their activity. However, other groups may seek to gain commercial advantage. Resilience against attack is dependent on both technology and governance. The following resources are available: GCHQ has developed '[ten steps to cyber-security](#)', holistic, corner-stone guidance for businesses and other organisations; the [cyber-security information sharing partnership \(CISP\)](#), for which membership is free but nomination is required (Simon could help); and [Cyber Essentials](#), a standard defining what good looks like for protection against commodity threats.

Simon noted that the US and UK are aligning on how to address cyber threats, and that many multinational organisations and Governments are pushing back such standards through their supply chains. Adoption of such security practices makes you a good partner to work with. The SBLC acknowledged that the FBI is doing a good job working with the synbio community in the US. A report on the recent UK-US policy meetings, at which cyber-security was raised, is available [online](#).

Off-the-shelf protection is designed to protect against 80% of commodity threats. However, we must also be aware of bespoke attacks, which are often well resourced and more difficult to stop. In the first instance, organisations must be aware of what data is important, who has access to it, what assurances are in place, what is the value of that data, and what would they do if it was lost. Attackers usually know what they are looking for, but company board members might not be aware of what they have. However

company boards must drive the culture of protection and provide suitable training, which should start with the basics. External advice is easily sought.

The SBLC recognises that pure data is vulnerable to attack, that cyber terrorism could pose a huge threat, and that the synthetic biology community must take this seriously. The way in which we control data is changing: more systems are automated, and virtual registries of parts are available online. However, we must manage the potential contradiction of open access and data protection. Simon has worked with UK universities to deduce what assets should be shared and which should be retained to maintain their value. Either way, it should be protected.

The SBLC also noted the role people play in cyber-security. However, many organisations are uncomfortable with security clearance, particularly when contributors come from across the globe. Katherina Yambao (Public Health Agency of Canada) noted that individual institutions should have robust systems to ensure personal security clearance.

Action 8-12: Prof Richard Kitney to raise cyber security with the SBRCs through the science and technology sub-group.

Action 8-13: Tim Fell to raise cyber-security with the BIA synthetic biology advisory committee.

Action: 8-14: Prof Lionel Clarke to consider how cyber-security might be included in the roadmap refresh.

5 Preliminary discussions around refreshing the synthetic biology roadmap for the UK

Lionel summarised the earlier discussion for the benefit of those who had just recently the meeting, highlighting the importance of translation & commercialisation, market opportunities, and the role of international partnerships and markets.

6 UK-Canada

Lionel summarised the meeting between the Canadian delegation and key members of the UK synthetic biology community, which took place on 17th March 2015 at the Quebec Government Office, London. The half-day meeting, dinner and attendance at this SBLC meeting are just some of the meetings in a weeklong visit to the UK organized by the UK science and innovation network in Montreal. The half-day meeting focused on: UK and Canadian strategies for synthetic biology; regulatory and funding frameworks; proposed mechanisms for co-funding; areas for collaboration in the future; policy; specific technological challenges, scientific capabilities and opportunities; health; and security.

Vincent Martin (Concordia University) noted that many upcoming Canadian grant programs require co-funding as leverage. As such, he is looking for opportunities for scientific research collaborations. Amanda summarised the MoU between RCUK and NSF (USA), which allows the lead agency to make decisions on projects and both fund the relevant eligible partners. This scheme is coming to the end of a two year pilot, although the advantages are likely to be much more long term. Amanda is happy to share her experience of it. Vincent noted that Canada was not involved in ERASynBio. ERASynBio is now coming to a close, but there are ongoing discussions regarding future activity.

Action 8-15: Dr Amanda Collis to connect Vincent Martin (Concordia University) to the German contacts developing a proposal to follow ERASynBio.

Danielle Kemmer (Genome Quebec) alerted the SBLC to an upcoming opportunity in August 2015, in which a Genome Canada call will allocate \$10M to projects with international academic and industrial partners. Applications must focus on the environment, forestry or mining.

Renaldo Battista (Fonds de recherche Québec en santé) thanked the SBLC for their candid sharing of information. It is now apparent just how important political support for synthetic biology has been in the UK. Graham Carr (Concordia University) acknowledged that the UK synthetic biology community and SBLC have the coherence to influence bioeconomy strategy in the UK.

The next steps in Canada are likely to be the formation of a knowledge network and raising synthetic biology at discussions between multiple funding agencies. The SBLC agreed that as each country independently defines the challenges we need to tackle next, we should both look for partnership and complementarity. One immediate area for cooperation may be the knowledge-based bioeconomy: Canada has multiple feedstocks that could feed a bioeconomy, and the SBLC is working with the IBLF, ATLC and various government departments on a bioeconomy strategy. Putting health aside, the necessity for high capital expenditure can be prohibitive for business. The UK is exploring a distributed manufacturing scenario. Vincent explained that, in Canada, sectors are often divided by natural resources. The forestry industry is moving from pulp and paper to chemicals and advanced materials, but the business model (centralized vs. distributed manufacturing) has not yet been defined.

Graham summarised the following additional areas for potential collaboration: alignment of funding opportunities; fostering mobility opportunities (such as through the MSc at Edinburgh, and other joint graduate programs); standardization of the regulatory environment; wider knowledge mobilization and knowledge brokerage; and public engagement beyond regulatory issues to develop a common voice. Vincent is also trying to obtain funding to build the infrastructure for a foundry in Montreal. He will engage with NIST regarding standardisation.

Joyce and her colleagues at the Innogen Institute have evidence that an onerous, costly and lengthy regulatory process favours incremental innovation and discourages radical innovation. Joyce acknowledged Canada as an excellent exemplar of how regulatory systems are used to support life sciences in agricultural biotechnology: the regulations are based on products and applications, not processes or technologies. Current discussions in the UK and Europe are linked to a process-based regulatory system, which could be inhibitory of innovation in the future. If the UK and Europe want to develop a regulatory system that is more amenable to disruptive innovation, we should move towards a product-based approach. Canada can help provide an evidence base to support it. Janet Bainbridge (UKTI) reminded the SBLC how important it is for discussions on regulation to be conducted in tandem with discussions on commercialisation and how it will impact on business. Sarah explained that Defra considers issues on a case-by-case basis, with the aim of identifying the most appropriate regulation in a pragmatic and proportional way. The definition of 'containment' is blurred: for example, physical containment vs. biological containment (when an organism is engineered not to survive).

Kathrina confirmed that Canada has submitted experts and observers for the AHTEG. Joyce, Sarah and Kathrina agreed to share information, build alliances and develop complimentary messaging. If Canada forms a national synthetic biology group, there may also be the opportunity to link further with the SBLC and similar groups in the US.

Lionel thanked the Canadian delegation for their participation. The delegation stayed for informal discussion over lunch, and then departed.

7 Commercialisation

Lionel welcomed David Hite (Bridge 37) and Ken Cooper (managing director, venture capital solutions, British Business Bank) to the meeting.

Chris Jones (Innovate UK) explained that many of the current synthetic biology projects have requested (and been granted) extensions, hence not many of the projects have yet reached their conclusion. Innovate UK will shortly launch a data, data management and data-driven biology competition. The KTN has recently worked with Innovate UK to publish a UK bioinformatics landscape, and there are lots of bioinformatics companies that could work more in this space.

James has targeted approximately 200 people with whom to directly engage as part of the roadmap refresh process. The analysis has revealed that many of them are not yet signed up to the SynBio SIG. Further community consultation is planned over the summer. UKTI, the BIA and the SynBio SIG are working together to publish a directory of UK synthetic biology companies in the June/July 2015. The SynBio SIG is working with colleagues within the KTN to explore the application of synthetic biology in different sectors. The 2015 synthetic biology leadership excellence accelerator program ([SynBio LEAP](#)) is also underway with seven UK participants (Sean Ward, Ted Fjällman, Lalitha Sundaram, James Field, Jon Marles-Wright, Nicola Patron, and Edward Perello).

8 Investor session

Ken Cooper (MD for VC solutions from the British Business Bank) briefly introduced the British Business Bank (BBB), an economic development bank and public limited company set up in November 2014 and 100% owned by UK Government. The aim of the BBB is to change the structure of the finance market to solve the problems that affect smaller businesses. The BBB uses public money and public policy in a commercial way. Private funds are often invested alongside public funds. The BBB helps companies: start-up (with mentoring and start-up loans); scale-up (with funding for high growth potential, growth loans, angel co-funds, an early-stage enterprise capital fund (ECF), and a late-stage catalyst fund); and stay strong (with more funding options and choice of providers, enterprise finance guarantees to back established companies, an enable program to allow banks to use capital more effectively to make more loans, and investment program loans). Companies do not have to be based in the UK, but must be in the EU. Investments cannot be made in the Channel Islands (such as Jersey and Guernsey) for tax reasons. In almost all cases the BBB works through one of more than 80 partners, rather than with companies directly. Companies that are rejected for a loan can be referred to a finance provider, such as the BBB, via a finance referral platform. The '[business finance guide](#)' publicises and explains potential funding options. The 'enterprise capital fund' (ECF) is probably the most relevant to the synthetic biology community.

Whilst applications are considered on a case-by-case basis, the BBB does monitor funding across different sectors and the eight great technologies to see what is (and isn't) being funded. To date, drug discovery has been a gap. Joyce explained that in December 2014, the Innogen Institute reported on innovative funding models for regenerative medicine. Such projects typically need public sector or philanthropic funding. The BBB is doing exactly this, albeit in a commercial way. The ECF has, in the past, been too heavy in capital-light programs and has lacked hard science. The BBB has introduced fund managers to Innovate UK, and there is significant overlap between those companies funded by Innovate UK and the BBB ECF. The SBLC considers the development of good case studies will help make UK companies more attractive to UK investors.

David Hite (Bridge 37) gave a brief background on himself and his company. He noted that in emerging markets wealth is often locked up in family offices that have previously invested in infrastructure. Such investors have often had a major say in the direction of the organization. They often have reservations regarding investing in venture, and particularly investing in technology. David has recently secured an \$8M fund, including \$4M from the Mexican Industry of Economy (MIE), and a further \$4M from family offices, private investors and personal funds.

Bridge 37 primarily considers investing in Silicon Valley (investment in Mexico is an exception as part of the negotiations with MIE). Bridge 37 is technology agnostic and to date has invested in: Crowdfunder (a crowd funding platform); Singularity University (which delivers programs to educate leaders from a variety of backgrounds on the acceleration of technologies and provides laboratories for start-ups) and access to a proprietary deal-flow; and a £2.5M fund to launch the Singularity University accelerator program (the proprietary deal-flow mentioned above), in which \$100,000 is invested in exchange for single digit equity.

Moving forward, Bridge 37 would like to participate in a fund that would co-invest in several different companies, not just one. Bridge 37 is considering establishing a satellite office in Europe, possibly London. David will attend SynBioBeta in April 2015 to gather information and build relationships.

David offered the following observations on the UK synthetic biology community:

- The UK needs more entrepreneurs, especially launching from universities. UK universities are doing excellent science but should be translating more.
- UK universities often demand an unusually large share of equity, which means the capital tables don't add up for investors.
- The UK needs better-prepared entrepreneurs, with greater business acumen that are willing to take some risks. They need coaching and help to develop their pitch. Lean Launchpad is helping to meet this need.
- There is an early-stage funding gap, although the BBB might help to meet this need.

The SBLC noted some of the differences between Y Combinator, which invests on an individual level, and Bridge 37, which is more institutional.

9 Summary for Minister and refreshing the synthetic biology roadmap for the UK

Lionel noted that it was a pleasure to see the Minister on budget day, and described the constructive discussions with the Canadian delegation, building on visits from David Willets and a UK delegation last year.

Lionel explained that the SBLC is in the process of taking stock of what has been achieved in the field in the last three years. We are reviewing what we've achieved and learned thus far and what we should do next. The vision from 2012 focused on benefits, enablers and technologies. We've seen significant investment in the research base through the seven SBRCs, plus capital investment in DNA synthesis. The research councils and Innovate UK have together developed a responsible research & innovation framework. SynbiCITE has been established to promote the adoption and use of synthetic biology by industry. The Rainbow Seed Fund is an early-stage venture capital fund for companies working in synthetic biology. Today the SBLC has heard from the BBB and US Investment Company Bridge 37. The SBLC continues to plan for success and to determine how the state can help develop disruptive technologies, for example with the development of standards and appropriate regulatory frameworks. The SBLC is engaged in good policy discussions and programs with international partners. The SynBio SIG now has almost 1000 members. An enormous amount has happened as a result of the roadmap. The SBLC is kicking-off a roadmap refresh to be finalised in the autumn after wider consultation.

Lionel noted that private investment in biotechnology is on the increase. The synthetic biology field is often compared to that of microelectronics, which suggests we are on a promising trajectory of global interest and growth. However, the UK historically failed to retain much of the resulting value of microelectronics in these shores, and we mustn't do the same with synthetic biology. The roadmap refresh asks how to generate maximum value from synthetic biology excellence within the UK and also how to retain it within these shores. In effect, we are turning the current roadmap on its head, starting with the need and working backwards, shifting focus from technology push to market pull. The ambition is to be inspirational and to identify grand challenges to which the aspirational synthetic biology community can respond in a disruptive, not incremental, manner. The potential application areas for synthetic biology are varied, broad and in some cases unknown. Lionel is working with the ATLC and IBLF to make sure the refreshed roadmap fits into a wider bioeconomy. We need better alignment along the funding landscape, both public and private, to get to market quicker. There are ways in which we can make the UK more attractive for private investment: for example, we could initiate a culture change in UK universities to reduce the equity they expect to retain in return for early investment to 3-5%, similar to levels in the US.

George Freeman MP congratulated the SBLC on the progress made thus far and reiterated his support for synthetic biology. Whichever Government forms in May, it will inherit industrial strategies, including life sciences and synthetic biology. Some funds have already been ring-fenced for sciences and capital investment. However, funding will inevitably be tight and the CSR will be competitive. In preparation for the CSR in the Summer, the SBLC should develop some 'retail messages' to help the Minister tell the story of how we can catalyse the progression of synthetic biology from something we do well to future applications.

The SBLC stated that the UK has a significant role to play at the intellectual level and that synthetic biology has the potential to be an industrial manufacturing platform for a sustainable future, with contributions in health, agri-tech, industrial biotechnology, regenerative medicine, renewable energy and beyond. Dale Sanders (John Innes Centre) offered vaccine manufacture in plants as a possible retail message. Currently

manufacture of 'flu vaccine must begin so far ahead of 'flu season that the vaccine is often ineffectual, as was the case in 2014/15. A modified plant can manufacture 10,000,000 doses of 'flu vaccine in 30 days, which allows manufacturers to delay vaccine design until nearer 'flu season when the seasonal strains are better characterized, resulting in a much more effective vaccine. It is also important to acknowledge that we can't yet imagine the infinite ways in which synthetic biology can be applied: an analogy would be giving someone a word processor and expecting them to imagine (and invest in) the internet.

The Minister asked the SBLC to consider what success might look like. Is it a platform technology? A spinout that might spawn more spinouts? Is it a cluster of SMEs developing tools and technologies? Is it the emergence of lots of companies? Is it a handful of large companies investing in the UK research base? Is it to be at the top of the metrics for deep science? Is it pulling significant inward investment? David Hite (Bridge 37) encouraged the SBLC to consider different business models. For example, electronic money can take the very different forms of Bit Coins or loyalty cards. There is an infinite number of potential business models for synthetic biology. A range of business models is likely to generate a range of benefits. The SBLC noted that the separation of design from construction lends itself to a distributed innovation system involving industry both large and small. Having a multi-national company start in the UK would be a clear success, as would drawing inward investment from the US. The co-development of software alongside wet laboratories is a real opportunity. The SBLC also considered the large volume of trained staff that the SBRCs will produce over the coming years. We need to generate an industry for them to move in to.

The Minister also recommended that the SBLC should define its ambition and develop the membership to match. If it is a forum for public-private partnerships, does it need more investors and more companies? Does it need to stay small and agile? How might it look in a few years?

Joyce summarised much of the activity of the SBLC Governance sub-group, which has focused on how to provide the best innovation environment and a constructive ecosystem to foster innovation without huge investment. The Innogen Institute recently reported on the development (or lack) of anti-microbial drugs. Through changes in the guidance for clinical trials, the cost was reduced by 50% and regulation is no longer seen as a constraint on innovation for antimicrobial drugs. If the EU regulatory system, as advised by House of Commons Science and Technology Committee, were to move from a process-based to a product-based approach, it would make a significant difference to Europe's innovation capacity.

The SBLC noted that, in two decades, the cost of DNA synthesis fallen by seven orders of magnitude. However, productivity hasn't progressed to the same degree, suggesting the rate-determining step is further up the supply chain. Bioengineering and automation will relieve this bottleneck, making synthetic biology quicker, more robust, cheaper, and potentially with tailored with bespoke characteristics (such as personalized medicine products). There is power in being able to construct lots of different things, and creativity can be monetised. With developments in both hardware and software, biology is reduced to digital information and synthetic biology is a computer science to control automated experiments.

The Minister encouraged the SBLC to develop a strapline to help provide clarity, and suggested the SBLC might wish to consider using variations on the 'biological internet of tomorrow', or 'smart 21st century manufacturing'. The Minister proposed that the SBLC articulate both short and long-term aspirations: in the short-term, we can use synthetic biology to solve problems; in the long-term, we can't yet imagine what the impact will be or what it will look like, but we know it will be big and different. We have a first-

mover advantage and are in a strong position. Different applications will come at different times. We need a strategy of identifying opportunities and demonstrating how we achieve them. It is important to state what we won't do, as well as what we will.

The Minister acknowledged the importance of building an integrated and appropriate regulatory strategy, and suggested that a summit on the bioeconomy, industrial biotechnology and synthetic biology could be included in the upcoming EXPO 2015 in Milan. Such an event could demonstrate how synthetic biology is facilitating the transition from oil-based feedstocks to alternative feedstocks for industrial products.

The Minister concluded by praising the value of embedding Tim Dafforn in BIS during his time as entrepreneur in residence for synthetic biology and encouraged the SBLC to be ambitious in their plans.

10 Summary of actions and final remarks

Lionel reminded the SBLC of the immediate need to create a coherent argument for the short CSR document in April and the forthcoming roadmap refresh. The discussion with the Minister helped define the necessary starting point: the essence of excitement and the retail message. The timeliness and need to maintain our international position should be reinforced: if we don't capitalise on our excellence and progress, someone else will. Possible terms and phrases for incorporation in the roadmap include: harnessing biosystems to work for us; the internet of life/biology; unlocking biological potential; and building and/or designing the conditions for self-assembly. Some SBLC members had concerns over the term self-assembly, which suggests a lack of control. The SBLC may also wish to call on the terms used in the science and innovation strategy: agility, place, excellence, openness, and collaboration. The refreshed roadmap must have a clarity of vision with examples, values, metrics, and a plan of how we coordinate ourselves to deliver.

The Formula One industry was used as an analogy. The UK has the necessary infrastructure and intellectual leadership to ensure value is retained in the UK. Technical centres develop products and processes and sell the technology to those that need it. We need to consider where value will be created and how we can create the best environment to capture it. The synthetic biology business model is unlikely to function as a conventional big company, but more likely a large number of small companies with a holding company, or a few larger companies with a myriad of smaller ones. The SBLC also reviewed the US company Amyris as an example of a successful synthetic biology company. The founders have since left to start new companies all over again. The UK must choose where to focus activity, and where not to. For instance, DNA synthesis has already been commoditised. Performing research on machines is also likely to be commoditized in the future. If the UK wishes to play in that space, a £50M investment in a pilot is required immediately before others offer the equivalent of Amazon Web Services for biological research. Incremental cost cutting might benefit British industry and could form a pipeline of delivery, but it is not a value proposition.

The market for synthetic biology is global but not homogenous: local solutions will be required around the world. If we wish to be the first to market, we need early intelligence of which markets are right, and how we can pick up others as they arise. It may be best to identify the challenges that synthetic biology can help and which don't have other solutions. Sue Dunkerton (KTN) suggested the SBLC may wish to seek advice from market analyzers or business schools, should any of them specialise in life sciences. The SBLC noted

that truly disruptive technologies develop their own markets, but that there are ways for the Government to support the creation of markets.

If the SBLC is to continue to have impact, the SBLC membership needs to reflect the synthetic biology community and activity in three years. The SBLC will draw comparison with how other groups are funded and supported. A review of membership will be included in the refresh of the roadmap.

Lionel thanked the SBLC members and invited guests for their participation before closing the meeting.

Summary of actions arising from SBLC8

Action 8-1: Prof Richard Kitney to initiate the involvement of industry (through the SBLC), Keltie and the Innogen Institute in the development of the EZ-MTA.

Action 8-2: Dr James brown to provide guidelines on use of the UK synthetic biology branding.

Action 8-3: All requests for SBLC responses to be sent to (i) SBLC secretariat, (ii) Prof Lionel Clarke and (iii) Prof Joyce Tait.

Action 8-4: SynBio SIG to launch an online calendar of events and activities, and to encourage community members to suggest items to be entered.

Action 8-5: Innovate UK, SynbiCITE and the SynBio SIG to meet quarterly to share industry contacts.

Action 8-6: Dr Amy Tayler to circulate the upcoming SBLC meeting dates: on 2nd July an extraordinary closed meeting of the SBLC to focus on the roadmap refresh; on 16th July an open meeting; on 22nd October a closed SBLC meeting.

Action 8-7: Dr Chris Jones to provide a paper and update on completed Innovate UK synthetic biology projects at a future meeting of the SBLC.

Action 8-8: Dr Amy Tayler to publish the agreed minutes of SBLC7 on the SBLC website.

Action 8-9: SBLC membership and proposed register of members' interests to be added to the meeting agenda for 2nd July 2015.

Action 8-10: SBLC members to consider registering for the online portal and/or membership/observation of the AHTEG.

Action 8-11: Alastair Kent or Joyce Tait to raise synthetic biology applications in medicinal products and the associated regulation at a subsequent SBLC meeting.

Action 8-12: Prof Richard Kitney to raise cyber security with the SBRCs through the science and technology sub-group.

Action 8-13: Tim Fell to raise cyber security with the BIA synthetic biology advisory council.

Action 8-14: Prof Lionel Clarke to consider how cyber-security might be included in the roadmap refresh

Action 8-15: Dr Amanda Collis to connect Vincent Martin (Concordia University) to the German contacts developing a proposal to follow ERASynBio.