



Synthetic Biology Leadership Council – Meeting 15, Open Meeting 4

Thursday 24th November 2016

**Christie Suite, Hilton London Kensington Hotel,
179-199 Holland Park Ave, London W11 4UL**

Attendees:

Lionel Clarke, Synthetic Biology Leadership Council co-chair
Sue Dunkerton, Knowledge Transfer Network
Tim Fell, Synthace and BIA Synthetic Biology Advisory Committee chair
Jackie Hinton, Department for Business, Energy & Industrial Strategy
Chris Jones, Innovate UK
Alastair Kent, Genetic Alliance UK
Richard Kitney, Imperial College London
Rowan McKibbin, Research Councils UK
Dale Sanders, John Innes Centre
Neil Stansfield, Dstl
Joyce Tait, Innogen Institute, University of Edinburgh
Amy Tayler, Synthetic Biology Special Interest Group at the Knowledge Transfer Network
David Tew, GSK

Invited participants:

Andrew Balmer, University of Manchester
Colette Matthewman, John Innes Centre
Robert Meckin, University of Manchester
Brigitte Nerlich, University of Nottingham
Barbara Ribreiro, University of Manchester
Members of the Imperial College London iGEM team 2016:
 Lisa Asher, Imperial College London
 Akash Bhattacharjee, Imperial College London
 Alice Boo, Imperial College London
 Alyssa Henderson, Imperial College
 Jonathan Li, Imperial College London
 Henry Lloyd-Laney, Imperial College
 Carys Moller, Imperial College
 Carter Teal, Imperial College London

Registered delegates:

Khaled Almuhammad, Aecenar
Richard Anderson, Sciad Communications
Ana Atanassova, Bayer CropScience
Alex Broomsgrove, EPSRC
Stephen Chambers, SynbiCITE
Andrew Cottam, Health & Safety Executive
Priyal de Zoysa, PineBio
Zoe Freeman, Synthace
James Hallinan, Cambridge Consultants Ltd
Richard Hammond, Cambridge Consultants Ltd
Yan-Kay Ho, UCL
Liling Lee, ocarrrt.com
Xiao Liang, University of Manchester
Ceri Lyn-Adams, BBSRC
Paloma Maraver, Jobseeker
Takashi Matsuura, KYOTO University European Centre
Patrick Philip, Quebec Government
Philip Reiser, SkyLab Bio
Filipe Rigueiro, Tamarind
Kathleen Sedgley, University of Bristol
Elena Seranova, SkyLab Bio
Guy-Bart Stan, Imperial College London
Pedro Tizei, UCL
Bethan Wolfenden, Bento Lab

1 Welcome & Introduction

Lionel Clarke welcomed everyone to the meeting, explaining that the Synthetic Biology Leadership Council (SBLC) is committed to operating in an open, transparent and effective manner with one open meeting each year. The format this year is to have a brief internal meeting followed by reports from the sub-groups (which have a wider membership and can address topics in more detail), and presentations on exciting ongoing activities including iGEM 2016, the OpenPlant fund, and case studies on responsible research & innovation (RRI). The afternoon will feature four discussion topics, in which contributions are welcomed from everyone.

The SBLC members briefly introduced themselves for the benefit of the invited participants and registered delegates.

2 Internal Business

The actions arising from the last meeting can be found in appendix 1. The following actions were marked as done: 14-1, 14-5, 14-6, 14-7, 14-9, 14-10, 14-11, 14-12, 14-14. The following five actions were discussed in more detail:

Action 14-2: *All SBLC members to send suggestions for potential new (predominantly industrial) members with a paragraph of justification to Amy Tayler by Thursday 28th July 2016.*

Following the last meeting SBLC members provided four names of potential new members, but they did not give sufficient coverage of different industrial sectors. Amy has since discussed SBLC membership with individual SBLC members to expand the list of suggested names, which has been circulated. SBLC members were invited to submit any additional names or comments before the end of the year.

Action 15-1: SBLC secretariat to consolidate and share the expanded list of potential new members in the New Year.

Action 14-3: *SBLC secretariat to revise declaration of interest template and circulate for comment and completion.*

At the last meeting the SBLC considered the guidance to be too focused on academics and potential conflicts rather than transparency. Amy has since revised the guidance, which has been circulated and is now approved by the SBLC.

Action 15-2: SBLC secretariat to share the revised template for the register of interest for completion by the SBLC.

Action 14-4: *Once the ministerial co-chair has been confirmed, SBLC secretariat to poll the SBLC members for 2017 meeting dates.*

Although the SBLC secretariat has been waiting for a new ministerial co-chair to be identified before setting dates for meetings in 2017, the SBLC agreed to go ahead and set meeting dates whilst discussions continued.

Action 15-3: SBLC secretariat to circulate a Doodle Poll to arrange dates for meetings in 2017.

Action: 14-8: *Joyce Tait to expand proposal (late paper 4a) to allow wider consultation with the BIA SBAC (via Tim Fell) and with the appropriate Ministers (via Lionel Clarke and Janet Bainbridge).*

An update will be provided under item 6.

Action 14-13: *All SBLC members to send Amy Tayler highlights from SBLC14 for inclusion in a Ministerial briefing by cop Thursday 21 July 2016.*

In the absence of a minister this briefing was not completed.

Lionel Clarke explained that the recommendations in the strategic plan 2016 are backed up by a more detailed action plan. By the time the next SBLC meeting comes around it will have been one year since the strategic plan was published. A summary of broader efforts beyond the SBLC would be beneficial for the next meeting.

Action 15-4: Amy Tayler to coordinate a summary of activities against the recommendations in the strategic plan ahead of the next meeting.

Lionel provided a general update in his capacity as SBLC co-chair. In September 2016 he joined a delegation to visit synthetic biology research centres and start-up companies in China, where considerable funding has been invested to develop the field. There is enthusiasm to work with us in the UK and we have an opportunity to develop partnerships and build relationships with these institutions.

Lionel also visited the US to participate in discussions with the National Academy of Sciences (NAS) and the Policy Office of the White House regarding appropriate regulation of synthetic biology. Contacts in the US are intrigued as to how the SBLC, the UK Roadmap (2012) and the Strategic Plan (2016) enable the UK to act in an agile, responsive and coordinated manner. Lionel observed what appear to be different approaches being applied: in the UK we have focused mainly on the development requirements of a broadly applicable toolkit for synthetic biology, whereas in the US the approach towards developing new technologies appears to be more goal-oriented, for example to tackle particular challenges. The UK would now benefit from some worked examples across the applications space demonstrating synthetic biology as a key enabling technology, and by identifying specific needs that can be addressed by synthetic biology in the future. All meeting participants have an opportunity to feed into this discussion in the afternoon breakout sessions.

Lionel acknowledged the value of the ministerial co-chairmanship of the SBLC, both with David Willetts and George Freeman. Lionel and colleagues in BEIS are actively engaging with ministers interested in the industrial strategy, biotechnology and the broader bioeconomy to seek co-chairmanship from an appropriate minister.

Lionel continues to work with the chairs of the Industrial Biotechnology Leadership Forum (IBLF), Agri-Food Technology Leadership Council (AFTLC), Chemistry Growth Partnership (CGP) and Medicines Manufacturing Industry Partnership (MMIP) to develop a bioeconomy strategy. The more we can bring to life some of the specific opportunities and challenges the more powerful the strategy will be.

3 AoB

Amy Tayler promoted the Dstl Centre for Defence Enterprise competition 'Synthetic Biology for Transparent Materials,' which is open until 2 February 2017. Neil Stansfield also highlighted an upcoming Dstl/Ministry of Defence synthetic biology workshop in February 2017, and extended an invitation to the participants. Amy noted that the SynBio SIG is working with Dstl to invite companies to the workshop, not just those in the synthetic biology community, but also those that could potentially use some of the tools and technologies being explored by Dstl.

The SBLC discussed challenge-led approaches. Neil noted that the recently announced National Productivity Investment Fund is more akin to the US DARPA model of funding. The Industry Strategy Challenge Fund (ISCF) will cover a broad range of technologies. Both Dstl funding and the ISCF will provide opportunities to support and

exploit synthetic biology R&D. Chris Jones noted that the current Dstl competition has identified a clear challenge that synthetic biology might be able to address. However, if we want to be more specific about industrial challenges, we need to tease out what the specific technology challenges are. These can be difficult conversations in the absence of worked examples.

The SBLC discussed the regulatory environment in the UK. Joyce Tait explained that the right regulatory systems are becoming increasingly important to the UK. Joyce expressed concern that it is difficult to get important work in regulatory sciences funded. The SBLC noted that in the US DARPA and NIST have co-invested to deliver programs that consider regulations for protection, commercial exploitation etc. Alistair Kent noted that the UK Medicines and Healthcare products Regulatory Agency (MHRA) sets the framework for regulation in the UK, which usually aligns with the EU regulations. The UK's soft power in interpreting the regulations could be reduced in light of Brexit, and we need to be alert to the tension. The SBLC noted that we need to be more creative in our risk assessment of biology.

Lionel invited questions from the registered delegates.

Guy-Bart Stan (Imperial College London) noted the focus on challenge-led research and asked whether there are any plans for discovery-led research, too. Rowan McKibbin (Research Councils UK) explained that the research councils are engaged in ongoing discussions and that they have a duty to continue to support the underpinning research. The SBLC noted that the roadmap and strategic plan have attracted additional funding for translation, rather than diverting funds away from fundamental research. It is hoped that challenges will inspire cross-disciplinary approaches, too.

3 Science & Technology sub-group

Richard Kitney explained that the science & technology sub-group, which meets a few weeks before each SBLC meeting, comprises the directors (or a nominee) of all the major synthetic biology research centres (SBRCs) plus the leaders of the doctoral training centres (DTCs) and the CEO of SynbiCITE (the Innovation & Knowledge Centre for Synthetic Biology). Highlights from the recent meeting included:

- an audit of training activities and business courses;
- the ongoing development of an Open Material Transfer Agreement (Open MTA) by the Biobricks Foundation and OpenPlant SBRC;
- metrics on UK synthetic biology; of approximately 60 companies exploring synthetic biology in the UK, 14 have been supported by SynbiCITE, and at the time of the meeting the Bio-Start competition has 34 applicants.
- and a report on recent synthetic biology start-ups compiled by Cambridge Consultants. The US dominates the start-up landscape in synthetic biology, but of those in Europe almost half are in the UK. In the UK our emphasis is on synthetic biology tools. The report notes that the SBRCs are yet to stimulate start-ups outside London and Cambridge, that accelerators play an important role in stimulating and supporting start-ups, and that start-ups have difficulty in accessing additional funding in the UK.

The SBLC noted the lag between basic investment and start-ups, hence the difficulty in mapping government funding to the areas in which start-ups are emerging. The SBLC also cautioned that this report is a snapshot and that companies are now spinning-out in Manchester, Bristol and Newcastle.

Spin-out companies are usually set up by PhD students and PDRAs rather than academic staff, although highly-experienced mentors are vital to help world-class scientists, engineers and less-experienced industrialists learn how to run a business.

The SBLC noted the important role iGEM plays in stimulating new synthetic biology start-ups: there is a long list of companies that are linked to either iGEM alumni or iGEM projects, predominantly in the US and UK. A large proportion of iGEM participants also stay in the field of synthetic biology, both in academia and in companies.

The SBLC discussed whether the bias towards UK companies developing tools and processes rather than products could be related to their reluctance to engage with inhibiting regulatory systems. In effect these companies pass on the responsibility to their customers rather than taking it on themselves. The whole value chain is dependent on any inhibitory regulations being addressed.

The SBLC noted that issues with intellectual property can inhibit innovation. For example, in pharmaceuticals and biotechnology prior art in the form of existing open source software can prevent commercially-driven innovation. Start-ups must do the necessary landscaping and seek advice to be sure they won't encounter problems further down the development pipeline.

The SBLC recognised that there are other ways to generate economic growth beyond start-up companies. In agri-tech, for example, it may be more appropriate to develop a new product or process in partnership with an existing player rather than establish a start-up. The SBLC acknowledged that these metrics are difficult to capture and are not covered by this report.

Start-up companies are inherently small and they need more long-term backing and infrastructure if they are to become productive medium-sized businesses. The SBLC noted the need for a skilled workforce, too.

4 iGEM 2016 update

Richard Kitney gave a brief introduction to iGEM, a student competition that generates working DNA parts using synthetic biology techniques with real world applications. The competition attracts high caliber students and the teams do fantastic work. 270 teams took part in the 2016 competition. Teams from across the UK had many successes in 2016, including the team from Imperial College London that won the undergraduate grand prize. This undergraduate team comprised bioengineers and life scientists, men and women, many of whom had taken the synthetic biology undergraduate course at Imperial College London.

Lisa Asher, Alyssa Henderson and Carter Teal (all Imperial College London) delivered the team's winning presentation. At the beginning of the project the team were brainstorming lots of big ideas, and quickly discovered that single cells couldn't meet their needs. Ecolibrium aims to exploit bacterial cooperation for our benefit. Bacteria are capable of forming intricate networks of complex interactions. The limits of monoculture could be broken if we can grow robust communities with multiple cell types. However, different cell types grow differently, and there are no protocols for co-culture. The team developed three modules to regulate the growth of two organisms in co-culture: a communication module that uses bidirectional quorum sensing, a comparator module that measures relative growth using RNA logic, and a growth regulator module that limits the growth of the more populous species to allow the lagging species to catch-up. The three modules have not yet been put into a single cell (the team would like to continue the project to reach this milestone), but the modules have been modeled *in silico* using both single cell and population models. The team was concerned that to the naked eye co-cultures won't look any different to mono-cultures. Therefore, they developed Biotone, 7 individual colours that create up to 77 different shades when co-cultured. Further work is needed to make the relative metabolic burdens of the different colours more consistent and to stabilise the colours. The team also created a visual media guidebook, infographics and a mobile game, still available for download, that was used at New Scientist Live. Their approach was inspired the STIR (socio-technological integration research) human practices protocol. The team is considering acquiring patents and establishing a spin-out company to commercialise their work.

The SBLC congratulated the team on their success, taking their idea all the way through to implementation in only 3 months.

5 OpenPlant Fund

Colette Matthewman (John Innes Centre) described the OpenPlant fund, which generate big impacts from relatively small, innovative, inter-disciplinary projects in plant synthetic biology. The OpenPlant fund was budgeted in the successful OpenPlant SBRC application to BBSRC & EPSRC. The fund provides up to £5,000 for collaborative projects between researchers at the Norwich Research Park and University of Cambridge. The projects foster synergies, support new collaborations, build a community, promote interdisciplinary working, provide open tools & resources, and explore broader RRI. To date the fund has supported 30 projects involving more than 26 organisations. With 50% of the awards going to PDRAs, >30% to PhD students and <20% to PIs, the fund provides a valuable opportunity for early-career researchers. The projects have delivered a range of outcomes including but not limited to outreach activities, biological material, hardware and software. Some examples include:

- The Big Algal Open Experiment: an open-source algal bioreactor that can be built from parts purchased from Amazon and is supported by an app. The project was taken to the Latitude Festival.
- A 'SynBio for schools' programme
- Strengthening synthetic biology capacity in Kenya

- Establishing an open synthetic biology lab in Abuja, Nigeria, where a workshop program will be established to up-skill local residents.
- Engineering spicy tomatoes
- Quick analytical systems for plastid genome modifications
- Advancing the ability to image single RNA molecules at the cellular level, which has generated a couple of publications and industry interest
- Hardware to monitor plant physiology
- Docubricks software for documenting open-source hardware
- Contentmine software for searching literature
- Open Pi-image software for image capture and analysis

Colette noted that the fund is not fully subscribed and that up to 20 projects can be supported each year. Colette works hard to discuss the opportunity with potential applicants to help stimulate ideas and applications.

The SBLC was impressed by what could be delivered with such little resource, particularly with regard to making synthetic biology meaningful to school children and realising its potential in the developing world.

6 Governance Sub-Group

Joyce Tait summarised the 9th meeting of the governance sub-group (GSG), which took place earlier in November.

The GSG continued an ongoing discussion about the regulatory context, the Convention on Biological Diversity (CBD) and whether it's being adapted. Synthetic biology is currently considered to be a new and emerging issue that either needs new protocols (which could be hazardous to the development of the field) or that should be treated as an extension of genetic modification (which is less uncertain). In the summer the CBD had broad participation and a balanced discussion, although the subsequent report may not have reflected the true multi-faceted nature of the discussion. However, the discussion is once again heavily influenced by environmental NGOs with less participation from industry and academia.

Colleagues from Defra provided an update on the Nagoya Protocol (NP), which aims to promote access and benefit sharing but could result in inhibiting access and reducing the realisation of benefits from synthetic biology. Nations that are the source of genetic materials should have the opportunity to benefit from the sharing of information, but the NP could result in a stalemate regarding who owns a particular resource, meaning no one has any benefit. It is likely that an insufficient number of signatories will agree to the current drafting of the NP, and negotiations will continue. The EU is drafting position papers and guidance notes that go beyond what is required by the CBD. These guidance notes will likely be challenged and they may not apply to the UK post-Brexit.

The GSG discussed the implications of Brexit with regard to innovation and regulation. In most areas the UK will benefit from complying with EU regulations so we can continue to access current markets. However, there are opportunities in areas in

which we do not trade with the EU (some agricultural related areas, for example). There is a need to fund more regulatory science.

Public communication with regard to specific synthetic biology tools and technologies was discussed by the GSG. For example, there is serious confusion between gene editing and gene drives, both of which use CRISPR/Cas9 technology. It is important that distinctions are made between gene editing (which is relatively benign and safer than existing technologies) and gene drives (which are designed to self-perpetuate in ecosystems and which contravene all current regulatory systems). The GSG will draft a communications strategy for the SBLC.

The GSG is helping address some of the recommendations in the Strategic Plan 2016:

- bringing together sector specific regulators to consider a more adaptive regulatory environment (recommendation 4.1). For example, in the US the FDA changed the guidelines for clinical trials of novel antimicrobials and cut the cost by half.
- exploring how guidelines and, in the longer-term, standards can support regulations (recommendation 4.2). For example, Joyce is working with BSI to explore the proportionate and adaptive governance of innovative technologies (including but not limited to synthetic biology) and aspirational standards for RRI.
- considering engagement and dialogues through an RRI approach (recommendation 4.4)
- balancing accurate information and involving the Science Media Centre (SMC) to provide media briefings as required (recommendation 4.5).

The SBLC value the early engagement of the appropriate regulatory authorities to enable synthetic biology to be taken forward without compromising safety. There is also a clear need for appropriate engagement and dialogue in our post-truth society.

Questions were invited from the registered participants.

One participant noted that it can be hard to find a communication mode that works and highlighted the need for communications science in addition to regulatory science. The SBLC agreed that chemical precedents don't work for biological systems and that regulators must understand the biology if they are to develop an appropriate regulatory system: it's easier to ask regulations to follow the science than it is for biology to obey the law. There is a need for expertise and dialogue in this area. Andrew Cottam (Health & Safety Executive) agreed that there is a need to understand the area to put an appropriate framework in place. As such, HSE recruits staff members with science backgrounds. There is also a new strategy for the health & safety system in the UK, in which keeping pace with change is a key theme. We must maintain safe innovation or UK plc. will suffer.

5 Responsible Research & Innovation

Brigitte Nerlich (University of Nottingham) described a series of 22 interviews with staff and students to get a feeling of what it is actually like to do synthetic biology

research. RRI is a great aspiration, but it is also very challenging for individual scientists to manage the demands of doing excellent science, generating opportunities for growth, and embedding RRI into their work everyday. The interviews have been analysed through thematic analysis and three over-arching narratives have emerged:

- bacteria to the rescue: speaking to the mission statement on the Nottingham SBRC website, using bacteria to turn waste to wealth.
- making bacteria work
- working with and getting to know bacteria: many researchers just want to know more about living things and how they work. Some participants were found to anthropomorphise them by singing to them, calling them their babies/children, demonstrating an intimacy between the researchers and their bacteria.

Three anxieties were also identified:

- time pressure to deliver products whilst balancing short and long-term risks and responsibilities: for example, how will my research affect global politics, and do I have any control over that?
- scaling-up: a need to improve productivity and scale-up.
- talking to the public without overselling what you can do.

In summary, RRI seems to be caught between slow, curiosity-driven research through which we get to know bacteria and making bacteria work for economic benefits now. There are also tensions between human and global scales.

Andrew Balmer (University of Manchester) is exploring the use of synthetic biology to make menthol as a worked example. Andrew's approach using the AREA framework: anticipating, reflecting, engaging and acting. Social scientists have been engaged in synthetic biology for many years. As a discipline we've done ARE but we need to act (A).

Andrew has conducted 30 scientists in the Manchester SynBioChem centre. Menthol is currently grown in India, and there was already sensitivity to the issues of using a synthetic biology approach to manufacture menthol. For example, an alternative production method could free up land for food production, it could reduce chemical usage, it could reduce the carbon footprint, it might develop tools that provide routes to other chemicals, there are concerns about the history of genetic modification and foods, concerns as to whether a synthetic biology label could harm relationships with industry/customers, and even it could close off an export market to India.

Andrew has organized pop-up events with tables of products containing menthol to learn more about what people think of menthol. For example: menthol is used in both 'good products' (pharmaceuticals) and 'bad products' (cigarettes); menthol products can be associated with rituals (going to bed and getting up); and menthol is important in family relationships (Mother's using menthol products on their children).

There is data to suggest that menthol cigarettes increase smoking frequency and increase the likelihood of children taking up smoking, hence menthol cigarettes will

be banned in the EU in 2020. This could generate a black market for menthol cigarettes.

RRI helps navigate the important entangled political, economic, political, ethics, outreach, training, and anticipation issues.

Questions were invited from the registered participants.

One participant noted that there is very little information in the public domain about thermophilic organisms and wondered whether oil companies might be responsible. It was Brigitte's opinion that the research is at the basic stage that is not readily picked up by the media.

Neil Stansfield noted that the way in which the public interacts with science and innovation in the US and UK is very different, and asked whether Brigitte and Andrew have any information on different cultural responses to synthetic biology. Brigitte explained that we don't yet know why 'frankenfoods' had a minor impact in the US but a major impact in the EU. There are cultural issues around GM in Germany and Austria. Similarly, Italy had a very strong reaction against Avian Flu whereas other countries didn't, and it's hard to pin down exactly why. Andrew acknowledged Claire Marris' work on cultural responses to GM, and agreed that a cross-cultural comparison on synthetic biology would be sensible. Joyce commented that one of the key factors in determining how nations respond is whom government listens to. For example, in Germany and Scotland, Government is heavily influenced by Green parties, and the US looks to the religious right (hence it has struggled with stem cell research).

Neil asked for examples of where the UK could do better and what we should avoid doing. Brigitte suggested 'gene surgery' might be an alternative to 'gene editing'.

Neil also asked about the role of social media. Andrew commented that Twitter is used by particular groups (academics, scientists and NGOs) and that it is used to link to blog posts, where the discussions take place. There are experts at the University of Manchester conducting ongoing work in this area.

Alastair noted that the idea of scientists being maternal/paternal about their bacteria is an interesting counter point to the stereotypical boffin. However, unethical companies will always act in an unethical way, and it's all about where synthetic biology is applied. There is a need to discourage detrimental users, not the products themselves, otherwise we will stifle positive outcomes. The SBLC discussed the balance of responsibility between the funders and researchers who develop the knowledge, and whoever takes it to commercial realisation. It's clearly context sensitive, and everybody has to take responsibility. The funders consider it during their assessment, but it can be very complicated to use notions of responsibility to making funding decisions on very early research when you can't predict what will happen much further down the line. The researchers must also consider their responsibilities as they are developing tools and technologies, and so must those that wish to commercialise the work. However, it's a complicated problem with far-reaching

consequences. For example, if a chemical company brings a new plant online, they can crash the price of a particular product, which stimulates farmers to grow new crops, which in turn puts someone else out of business. It can be hard to work out where to draw the line on considerations.

Andrew explained that a network of RRI experts is growing in the UK and they meet regularly. They would like to develop a national RRI platform with a registry of tools and techniques.

6 Breakout sessions

All meeting attendees were invited to participate in breakout discussions on the topics of (i) RRI, (ii) applications of synthetic biology, (iii) the SBLC and (iv) Brexit. Participants were welcome to stick to one topic or move amongst the discussions. The discussions were summarised as follows:

(i) RRI: facilitated by Robert Meckin & Barbara Ribeiro (University of Manchester)

Different people have different concerns about RRI, including:

- how is RRI translated into practice from lab to market?
- how can IP be protected in an RRI framework?
- what would happen as RRI is moved into the market?
- are we communicating the findings and sharing them effectively with other people?
- are there different international approaches? For example, between the UK and China.

There is an opportunity to draw on the FCO Science & Innovation Network (SIN) to try and get a global view of RRI, and to develop an RRI cross-network involving other technology areas such as nanotechnology. Andrew suggested that we need to show the value of RRI using case studies of how it fits with commercialisation.

(ii) Applications of synthetic biology: David Tew (GSK) and Tim Fell (Synthace and the BIA Synthetic Biology Advisory Committee)

Potential application areas included how to heal people (vaccines, biologics, a generic vaccine, antimicrobials), feed people, fuel the world and use synthetic biology as a manufacturing technology. However, we need to reduce the complexity of biology to complications we can manage. Standards, metrology and analytics will give us the necessary engineering framework.

(ii) SBLC – Lionel Clarke

Lionel summarised a range of ideas of activities for the SBLC. It is unlikely that the SBLC will be able to implement all of them, but it can certainly consider them.

- Identifying what the UK is capable of doing and feeding in to industrial strategy and ISCF, painting a clearer picture of where we are, what we are doing, and what's holding us back.
- Advocacy and influencing, with mechanisms to provide information back to the SBLC.

- Helping to attract further investment from patient investors that don't dilute the value of start-ups too early.
- Identifying what investors are looking for.
- Continuing to engage the community, pulling together the success stories.
- Identifying what follow-up support and funding is available.
- Providing access to automation facilities.
- Providing access to mentors and learning from others experiences
- Follow-up to IKC training to further assist new companies

(iv) How can synthetic biology contribute to Brexit decision making, and how will Brexit affect synthetic biology? Facilitated by Joyce Tait (Innogen Institute, University of Edinburgh).

The discussion was summarised as follows:

- In some areas regulatory systems will get more difficult and the soft power the UK has been exercising will disappear. Without the UK to moderate regulations in the EU could get worse.
- The UK has an opportunity to show a different approach to GMOs. If we can show how it can be done differently and made easier & less costly with the same levels of safety, we might eventually influence the EU, too, leading to more adaptive and flexible EU regulatory systems, with which the UK will still have to abide to trade with the single market.
- More right wing, authoritarian regimes may change Europe, making it less in favour of strengthening regulatory systems for their own sake, instead focusing on other things.
- Brexit will likely cause personnel issues, reducing freedom of movement and making it harder to collaborate. SMEs are likely to suffer more than multinational companies.
- The best outcomes of Brexit will be the ones that take longer to happen, the more immediate outcomes are more likely to be negative.

7 Closing remarks

Lionel thanked everyone for their participation, energy and contributions in the breakout session: the open meeting always brings new dimensions to the SBLC. In particular, Lionel thanked the invited participants for their presentations and facilitation. Lionel also thanked Sue Dunkerton for her contributions to the SBLC. Sue is stepping down from the SBLC and at future meetings the KTN will be represented by Yvonne Armitage.

Action 15-5: SBLC secretariat to draft the minutes of this meeting.

Summary of actions arising from SBLC14

Action 14-1: SBLC secretariat to make two amendments to the minutes of SBLC13 and upload to the SBLC website.

Action 14-2: All SBLC members to send suggestions for potential new (predominantly industrial) members with a paragraph of justification to Amy Tayler by Thursday 28th July 2016.

Action 14-3: SBLC secretariat to revise declaration of interest template and circulate for comment and completion.

Action 14-4: Once the ministerial co-chair has been confirmed, SBLC secretariat to poll the SBLC members for 2017 meeting dates.

Action 14-5: Amy Tayler and Richard Kitney to record Science and Technology sub-group activities against the recommendations in the strategic plan.

Action 14-6: SBLC secretariat to send minutes of the Governance sub-group to Richard Kitney for circulation amongst the Science and Technology sub-group.

Action: 14-7: SBLC secretariat to upload the minutes of the 7th and 8th Governance sub-group meetings to the SBLC website.

Action: 14-8: Joyce Tait to expand proposal (late paper 4a) to allow wider consultation with the BIA SBAC (via Tim Fell) and with the appropriate Ministers (via Lionel Clarke and Janet Bainbridge).

Action 14-9: Henry Wormersley-Smith to connect the SBLC to the National Counter Terrorism Security Office.

Action 14-10: Neil Stansfield to share global synthetic biology report with Richard Kitney to circulate to Science and Technology sub-group.

Action 14-11: All SBLC members to provide amendments to UK bioeconomy statement to Lionel Clarke by cop Monday 18th July 2016.

Action 14-12: Amy Tayler to draft agenda for SBLC15 open meeting and circulate for comment.

Action 14-13: All SBLC members to send Amy Tayler highlights from SBLC14 for inclusion in a Ministerial briefing by cop Thursday 21 July 2016.

Action 14-14: SBLC secretariat to draft SBLC14 minutes.

Summary of actions arising from SBLC15

Action 15-1: SBLC secretariat to consolidate and share the expanded list of potential new members in the new year.

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