

Policy Levers and Strategies

Making the Living World Engineerable - Synthetic Biology, the UK Approach

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NAS, Washington D.C.

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**Note: presentation represents a personal reflection, not an official view of the SBLC*

What is the (*UK Synthetic Biology*) Roadmap? 1

- To develop emerging platform technology with multiple potential applications into an effective capability delivering clear value
- NOT a project plan to a fixed target ... a straight road...
 - ... more like a hiking map in unfamiliar territory*
 - ... or perhaps a guide to setting up a National Park – where to build paths and bridges, where to post warning signs and set up safety barriers...*

What is the (*UK Synthetic Biology*) Roadmap? 2

- **Driven by unmet needs, spanning health to sustainable energy**
 - not a project plan towards a set end point, yet purposeful
- **A guiding framework, reflecting committee consensus**
 - aligned behind a common vision and value system
 - relevant departments and stakeholders remain responsible for delivery
- **Speed and efficiency enhanced by anticipating future applications**
 - Stimulating discussions and actions well in advance of potential deployment
- **Mechanism for assessing progress and reshaping as needed**
 - follow-up documents build upon original Roadmap foundation, not displace

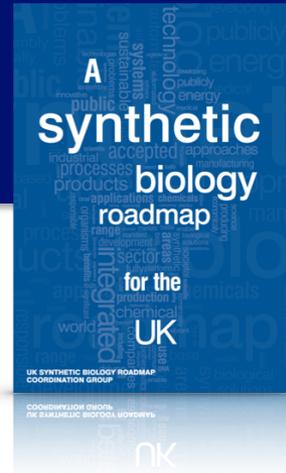
The UK Approach

- **Synthetic Biology identified as a potentially significant scientific growth area with academic strength in the UK**
 - Public Dialogue 2011 provided preliminary guidance
 -but how to realise its potential?
- **Convene a Roadmap Coordination Group**
 - Led by an industrialist, but with key stakeholder representation
 - Broader engagement via workshops and Special Interest Group
 - Government observers, but independent recommendations
- **Convene a Leadership Council to oversee progress, update and re-steer as needed**
 - Sub-groups and Open Meetings to enable more inclusion and engagement

Vision:

...of a synthetic Biology Sector that is:

- **economically vibrant, diverse and sustainable:**
where businesses are successfully developing and introducing new products, processes and services – leading to significant revenues and employment
- **cutting edge:**
leading scientific advances and with a resilient platform of underpinning technologies – delivering clear advantages in application development
- **of clear public benefit:**
an exemplar of responsible innovation, incorporating the views of a range of stakeholders and addressing global societal and environmental challenges within an effective, appropriate and responsive regulatory framework



Value System

- Learn from past – GMOs and other experiences
- Technology must be developed in a socially responsible fashion – ‘Responsible Research and Innovation (RRI)’
- UK needs to be, and be seen to be, leading the way in frameworks and methodologies for RRI
- Relevant Stakeholders, Regulators and Publics should be engaged in processes from outset; *Society has to be Enrolled*
- Gather preliminary views via Public Dialogue (2011)

Responsible Research and Innovation

five key questions that synthetic biologists should be willing and able to answer:

- what is the purpose?
- why do you want to do it?
- what are you going to gain from it?
- what else is it going to do?
- how do you know you are right?

Added to which we should also be prepared to consider:

- What may be the consequence of not doing?

Synthetic
Biology
Dialogue

Διάλογος
Βιοϊατρική

2011

1+6 SBRCs, 2 DTCs & 1 IKC established: Extending UK Foundational and Translational Capability

CSYNBI

Centre for **Synthetic Biology and Innovation**
Imperial College London



2009



OpenPlant

OPEN TECHNOLOGIES FOR PLANT SYNTHETIC BIOLOGY

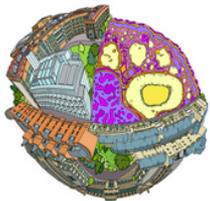
Cambridge University and John Innes Centre



SYNBIOCHEM

Manchester Synthetic Biology Research Centre
for Fine and Speciality Chemicals

**Warwick Integrative
Synthetic Biology
Centre**



BrisSynBio

biomolecules to biosystems
from understanding to design



**UK Centre for
Mammalian
Synthetic Biology**



SYNBICITE
SYNTHETIC BIOLOGY INNOVATION
COMMERCIAL AND INDUSTRIAL TRANSLATION ENGINE



Synthetic Biology Doctoral Training Centre



SBRCs: Synthetic Biology Research Centres

DTC: Doctoral Training Centres

IKC: Innovation and Knowledge Centre





UK Synthetic Biology Leadership Council

Co-Chairmen:

Prof. Lionel Clarke

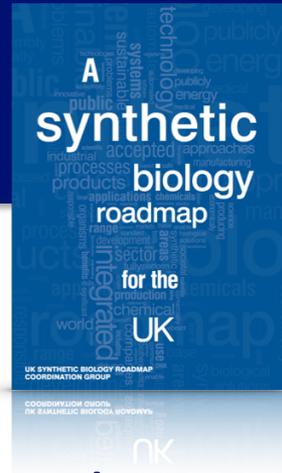
Rt. Hon. David Willetts (2012-14)

George Freeman MP (2014-16)

- +Governance sub-group
- +Sci & Tech sub-group
- +BIA SynBio Advisory Committee also working with BSI, NPL

Synthetic Biology

– an advancing frontier?



Synthetic Biology stems from confluence of modern smart data-intensive technologies with advancing biological understanding at the genetic level

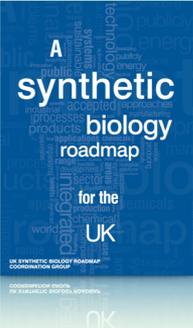
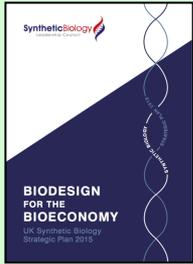
➤ **‘Analogue to Digital Revolution in Biology’**

As a result of greater automation and the application of engineering principles of characterisation, standardisation and modularisation to biological systems, predictability and development speeds can be increased and costs reduced

Domain of Synthetic Biology

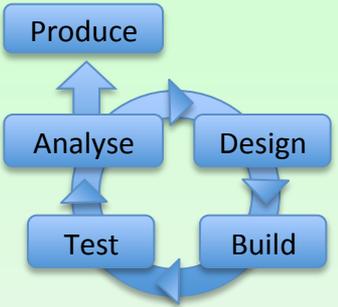
Biodesign

*Design-to-outcome processes accelerated
Speed and Predictability increased*



Advancing Biological Understanding

Advancing Smart Data-Intensive Technologies



Rapid, accurate gene-editing tools developed (e.g. CRISPR)

Registries of standardized parts

'Digital'
↑
'Analogue'

Costs of Reading and Writing DNA reduced

Costs of data handling and analysis reduced

High Throughput Analysis techniques developed

Engineering Principles of characterisation, standardisation, modularisation

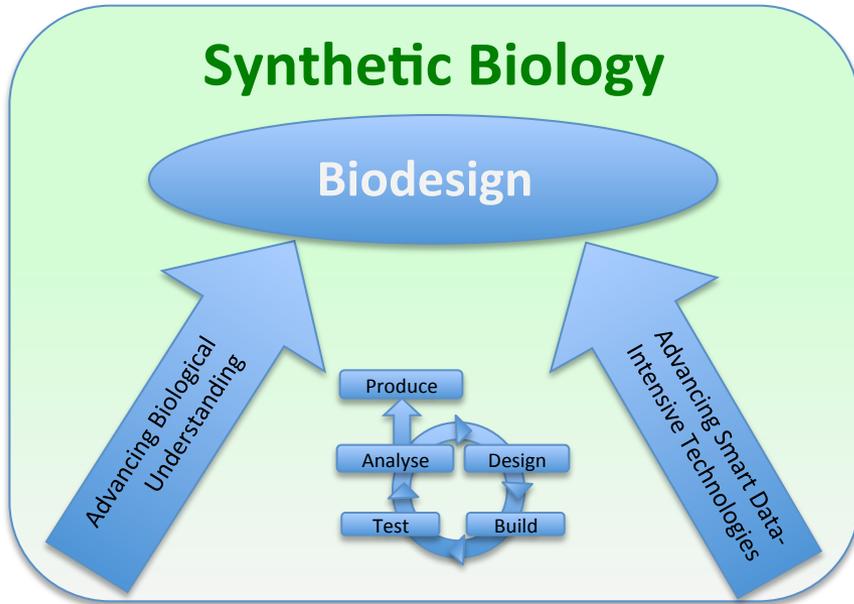
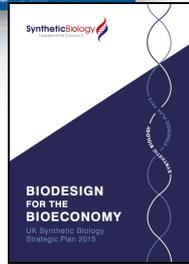
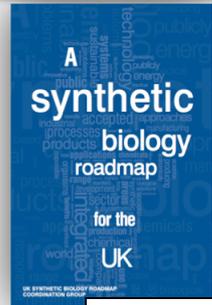
1990-2003 Human Genome Project

1984: DNA fingerprinting

1970's: genetic engineering developed

1953: Discovery of structure of DNA *Crick and Watson*

Synthetic Biology: a timely response linking technological potential to market needs



'Rapid but not Hasty'

value system, regulatory development, governance and social engagement embedded in Roadmap and Strategic Plan

Rapid Technological Development

DNA sequencing, synthesis and automated high-throughput analysis increasing speed and predictability

DNA design and gene assembly becoming much cheaper and more widely accessible, facilitating routes to innovative bio-based solutions



Population
Quality of Life — **Environment**

<p>Well-Being</p> <ul style="list-style-type: none"> Predict/Prevent Diseases Personal Healthcare & Lifestyle Employment 	<p>Security</p> <ul style="list-style-type: none"> Food Water Energy 	<p>Sustainability</p> <ul style="list-style-type: none"> Manage natural resources Reduced dependence on non-renewable sources Climate Change mitigation
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Ref: UK Synthetic Biology Roadmap July 2012

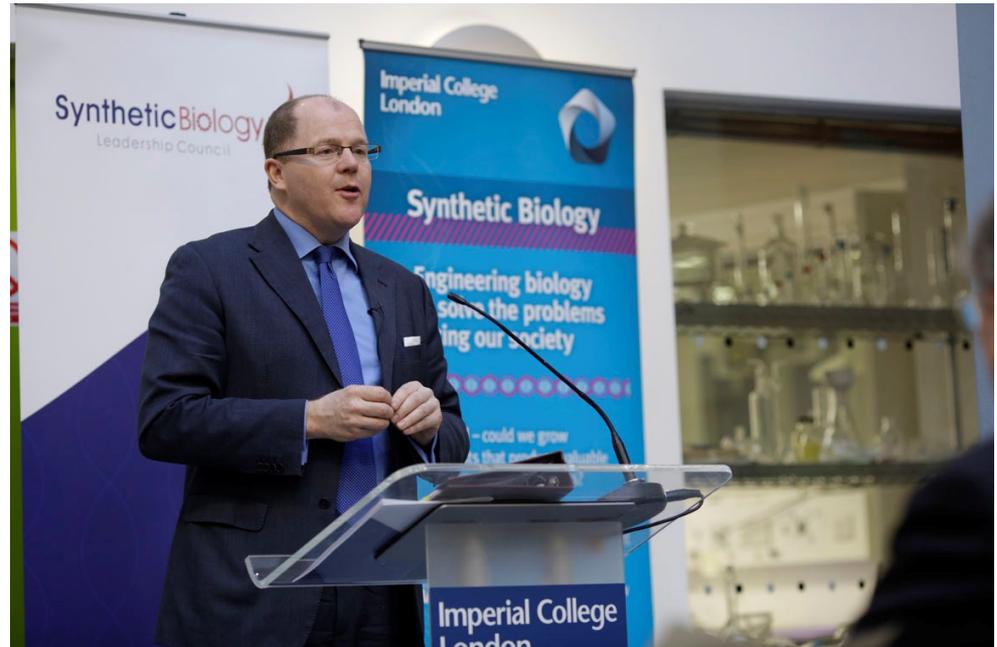
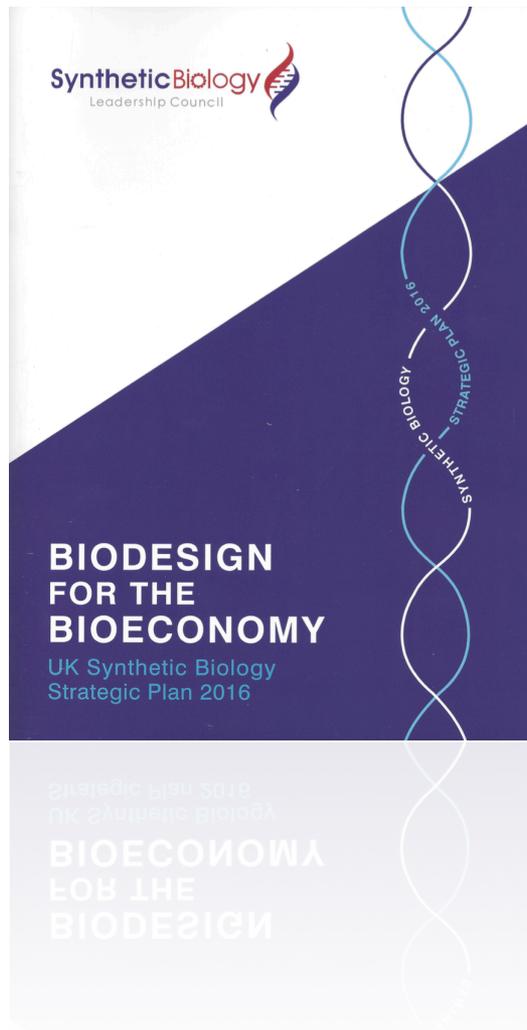
Global Challenges and Needs Increasing

effective new solutions becoming technologically possible and commercially viable

Commercial considerations provide a further set of checks and constraints

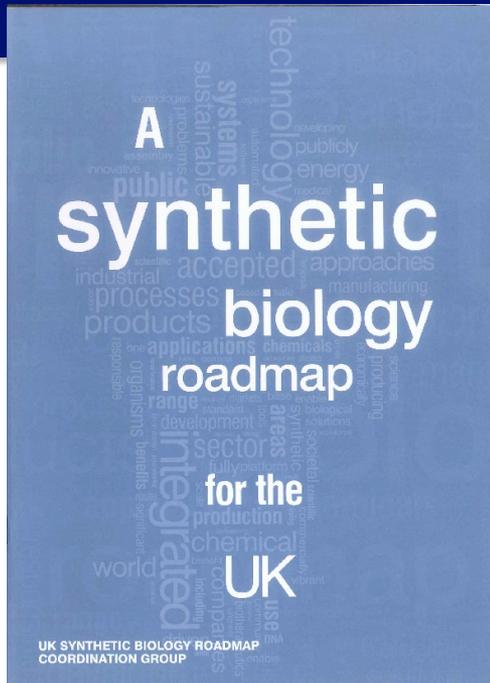
- What is the need?
- How effective are current solutions?
- How could an improved solution help?
- How could synthetic biology contribute towards generating this solution?
- How will suitability and acceptability be checked?

UK SynBio Strategic Plan 2016 Launch Event: 24 Feb 2016



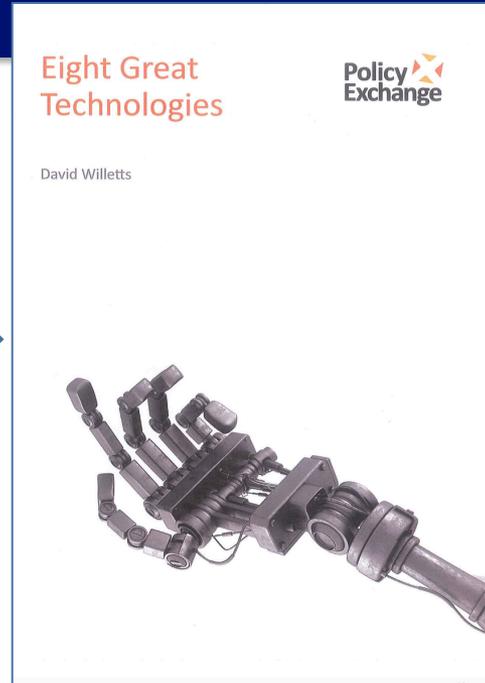
<https://connect.innovateuk.org/web/synthetic-biology-special-interest-group/2016-uk-synbio-strategic-plan>

Synthetic Biology UK: an independently coordinated response to a strategic challenge



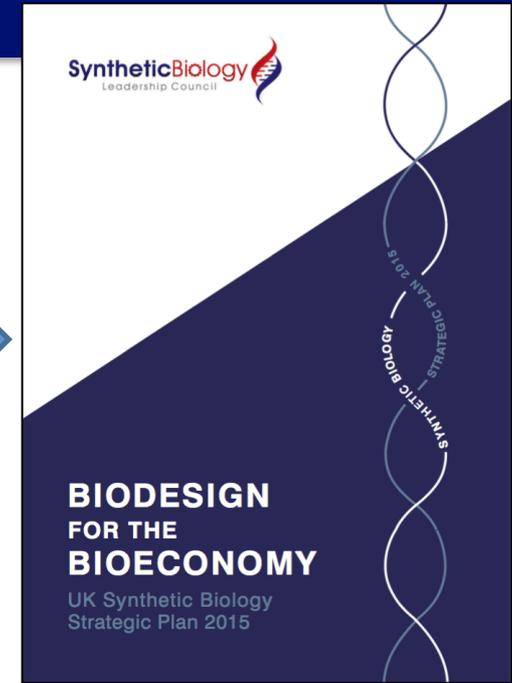
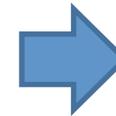
July 2012

Roadmap: Building Foundations
- multidisciplinary centres,
community and value systems



Jan 2013

Synthetic Biology Policy:
one of the
'Eight Great Technologies'

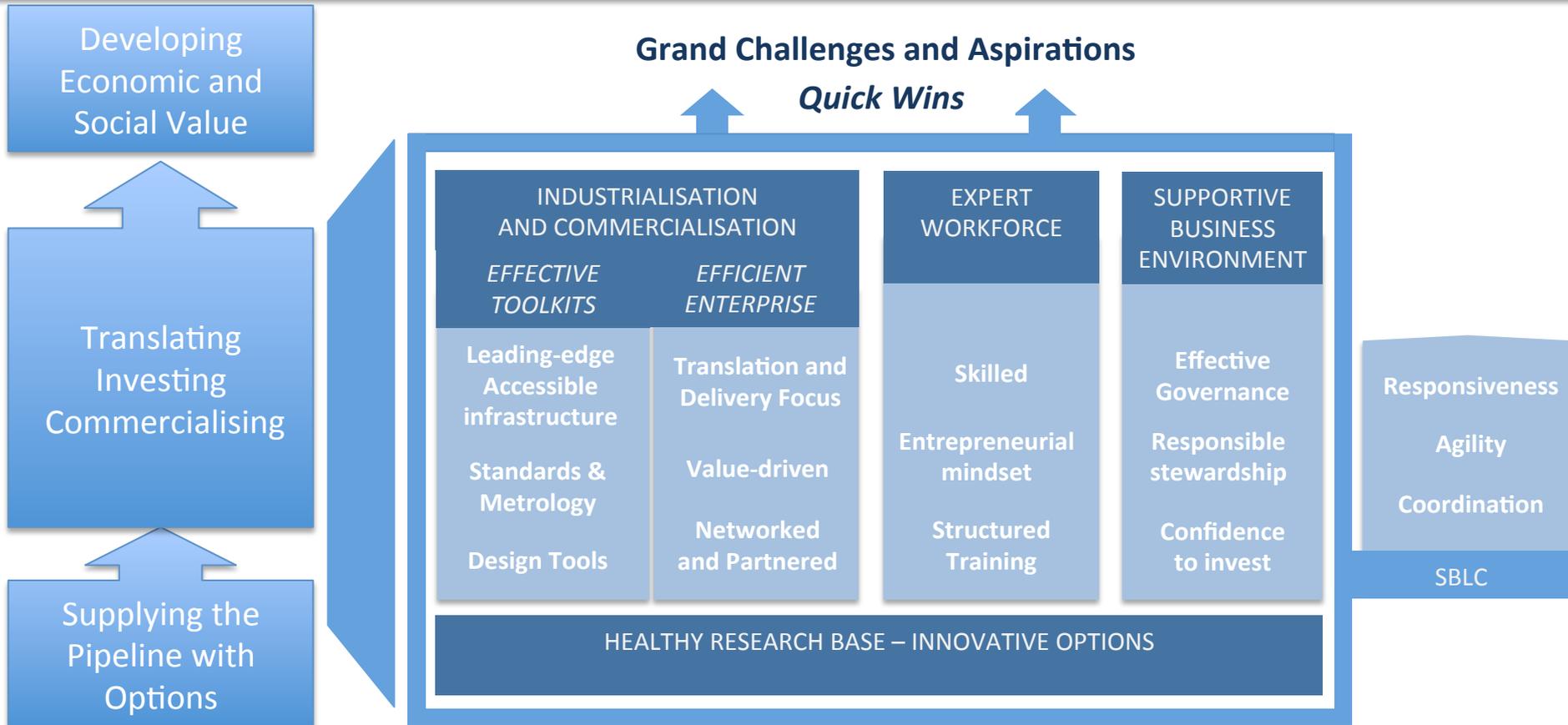


Feb 2016

Strategic Plan 2016:
commercialising
applications

Synthetic Biology – 2016 UK Strategic Plan

mapping out routes to industrialisation and commercialisation from innovative research base



UK Synthetic Biology – International Partnerships

- **UK has set out to be amongst the world leaders in synthetic biology. Coordinated investments and initiatives helping to achieve and benefit from this.**
 - over £300m invested in R&D to date, plus private investments. Second only to the US.
 - seeking to leverage investments to date to retain initiative and attract further investments
- **Information-based platform lends itself to geographically distributed operations**
 - opportunities arising in developing as well as developed markets
 - UK-based commercial applications for developing markets include arsenic sensor for clean water, control of mosquito-borne diseases such as Zika, bespoke drugs and vaccine production
- **International partnerships an important feature of recent development of the field**
 - shaped through workshops and joint research programmes with US, Europe, China and others
 - seek role as ‘partner of choice’ – valuable in establishing standards, regulations, access to markets
 - international training and research partnerships include LEAP, synberc, iGEM and ERA-SynBio



Thank You