

**Feb 10**

**Apr 10**

**Oct 09**

**May 11**

**May 09**

## **JOURNEY**

# **INDUSTRIAL BIOTECHNOLOGY:**

**The opportunity for growth**

**Jul 14**

**Dec 12**

**Nov 13**

**Jan 13**

**Aug 13**

## Foreword from Steve Bagshaw, IBLF Chair

It's now five years since the publication of the Industrial Biotechnology Innovation & Growth Team (IB-IGT) report on the potential for industrial biotechnology in the UK, and the **'Journey of Industrial Biotechnology: the opportunity for growth'** demonstrates just how far we've come.

My own personal and my company involvement in this IB journey combined when I joined the IBLF as leader of a Task Force to capture success stories, to provide quantitative measures of progress, to identify where future uptake of IB will most likely be realised, and to establish realistic milestones for 2015 and beyond. In January 2013, I was delighted to follow in the footsteps of Ian Shott CBE and accept the role of Industrial Biotechnology Leadership Forum (IBLF) Co-Chair.

The IBLF brings together those from industry (large and small), Government, funding bodies, related associations and the skills councils. The wider Industrial Biotechnology Special Interest Group, with almost 2,000 members, has industrial participation from all parts of the supply chain, allowing technical and market experts to connect. Together, we have implemented the recommendations of the IB-IGT report to produce a capable and connected UK IB community of critical mass.

**'Journey of Industrial Biotechnology: the opportunity for growth'** celebrates our achievements thus far and shows we are well on the way to achieving £12Bn in value to the UK economy by 2025. However, industrial biotechnology is a tool for use in many applications, and I hope this document will also inspire us to capture the true potential of IB in a range of markets. It's time for us to broaden our connections to make best use of feedstock, and explore further applications in medical biotechnology, pharmaceuticals, biofuels and bioenergy as well as the production of chemicals, flavours and fragrances.

I recently started an exciting partnership with the industrial co-chairs of the Synthetic Biology and Agri-tech Leadership Councils. Together, we aim to make the UK an attractive and vibrant place in which to imagine, innovate, develop and commercialise new products and processes, ensuring that the industrialisation of biotechnology will drive and deliver a wider UK bioeconomy. I hope you'll join us on our journey to 2025 and beyond.

**Steve Bagshaw,**  
Industry Chairman, Industrial  
Biotechnology Leadership Forum



Steve Bagshaw, IBLF Chair and Chief Executive Officer at FUJIFILM Diosynth Biotechnologies

## Executive Summary

Five years has passed since the Industrial Biotechnology Innovation and Growth Team (IB-IGT) published IB2025 – a horizon-scanning and road-mapping report on **'Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy'**. This document will take you on a "Journey of IB" to give you an update on what has been achieved in the UK in the last 5 years. It will review the rapid growth of the uptake of industrial biotechnology (IB) across the chemistry-using industries since the publication of IB2025, whilst highlighting the challenges that remain. The IB-IGT made over 20 key recommendations in the 2009 document, which were broadly split into five themes. The **'Journey of Industrial Biotechnology: the opportunity for growth'** demonstrates how the UK is measuring up against these recommendations.

### 1: Connecting it all together

In 2009, a significant communication gap existed between upstream and downstream supply chains. The Industrial Biotechnology Leadership Forum (IBLF) has overseen the implementation of the 2009 recommendations, and has supported and delivered a number of high profile events, thus establishing long-lasting connections across a broader biotechnology base. Future focus should be on supporting and nurturing the commercialisation of IB products, processes and start-up companies from the large pipeline of new projects.

### 2: Facilities and funding

One of the specific recommendations included development of an open access fermentation demonstrator facility. Following funding from the Department for Business, Innovation and Skills (BIS), the Centre for Process Innovation (CPI) successfully installed new 10,000L scale demonstration facilities which have since been utilised by 65 companies. Innovate UK, with support from the Biotechnology and Biological Sciences Research Council (BBSRC) and the Engineering and Physical Sciences Research Council (EPSRC), have also led in the delivery of 5 annual strategic funds for IB innovation and demonstration.

### 3: Innovation and knowledge transfer

Early progress was made through IB being identified as a strategic priority by both Innovate UK and BBSRC, facilitating numerous funding mechanisms and opportunities for knowledge exchange to be established and accessed by academia and business. Innovate UK have also financed a dedicated company engagement programme to raise awareness of commercial opportunities around IB, lower barriers to entry, and support research with high commercial impact, which was delivered by the KTN. Subsequently, BBSRC's initiation of the Networks in Industrial Biotechnology and Bioenergy (BBSRC NIBB) and the co-ordination of the IB Catalyst Fund have been instrumental in delivering the recommendations in this area.

### 4: Skills

It is impossible to grow a research sector without a highly skilled workforce, and the provision of doctoral training programmes and a multi-disciplinary MSc course across the UK have helped to build a firm foundation in academia. In addition, Cogent has established that the skills gap extended beyond academia and launched a Gold Standard award for process technicians in biotechnology. GSK has also led on the development of a Science Industry Partnership (SIP) for process industries.

### 5: Perception and awareness

As with all new sectors, there is a need for a supportive 'public' and 'business' environment to grow. To that end, consistent language around IB, coupled with examples of benefits to society, is currently being developed in line with the recommendations from the "Sustainable Returns: IB Done Well" report published by Jonathon Porritt. In addition, a new Publicly Available Specification (PAS) guidance document, facilitated by the British Standards Institution (BSI), was launched in November 2013, which focuses on the production, use and disposal of bio-based products.

As well as assessing progress against these recommendations, the **'Journey of Industrial Biotechnology: the opportunity for growth'** highlights a number of innovative case studies from across the IB landscape, which clearly demonstrates the potential for commercial success in this sector. These success stories are backed up by encouraging words from some of the sector's leading figures. Taken together, there is strong evidence that the future of IB looks bright.

## Case Study: Strategic partnerships help Ingenza to grow

Ingenza are at the sharp end of the biotech market – engineering microbes for a range of applications. Over the past five years, they have grown significantly with a three-fold increase in both revenues and staff. Ingenza is now a world leader in the application of IB and synthetic biology. For Ingenza MD, Ian Fotheringham, collaborations are the key to innovation, **"many companies believe that IB can significantly benefit their business, but don't know how to develop and establish the necessary biotechnology. Organisations like the IBLF bring these new players together with innovators like us."**

Ingenza recently collaborated with Synthomer – a top five global supplier of emulsion and speciality polymers. Following an IBLF networking event, Synthomer were keen to explore the application of IB to their products, and in partnership with Ingenza, were successful in procuring Innovate UK support for a feasibility study.

The collaboration demonstrated the potential benefits of engineering a microorganism specifically for use in Synthomer's manufacturing systems. This is now being followed by a second, larger collaborative proposal to demonstrate the viability of the same processes.

Fotheringham suggests that the small IB business innovation sector in the UK is enjoying sustained growth. **"A decade ago SME-based collaborative research was far more prominent in the US, but now the UK is outperforming its larger neighbour."**

## Case Study: Government backing and new industry connections help Croda grow IB offering

Croda, a UK based world leading speciality chemicals manufacturer, has significantly developed an IB portfolio in the last five years with the help of new contacts and funding made accessible through the UK strategy for IB, supported by the IBLF.

Four years ago the company opened a new fermentation facility in Widnes to manufacture biotechnology products, before acquiring an Italian company, IRB that produces ingredients through plant cell technology.

The Italian facility joined an existing business in France, where investments in capability have increased numbers of employees in the past five years. In the same space of time, the UK plant has doubled its number of full time scientists.

This growth has helped to increase Croda's product portfolio with the addition of new fermentation products for the personal care market, whilst collaborative funded projects

with Innovate UK have allowed further investment in the Widnes site.

**"The Government seems to have backed what they feel is an important technology,"** says Dr Surinder Chahal, Croda's VP for Research and Technology. **"This commitment allows our business to invest in commercially focused research with more immediate impacts."**

## Industrial Biotechnology Leadership Forum

The Industrial Biotechnology Leadership Forum (IBLF) was established in 2009 to bring industry together with other critical stakeholders from funding bodies and Government, to define the strategy that will help the UK realise IB's £12bn market potential.

Sponsored by BIS, with secretariat provided by the Knowledge Transfer Network (KTN), the forum was a front-runner in BIS' industry-led strategy groups. The IBLF has overseen the progress and delivery of the 21

IB-IGT recommendations and has provided industrial steer and prioritisation to the IBLF delivery partners in Innovate UK, the KTN, BBSRC, EPSRC, Cogent and IChemE.

### IBLF Members 2015

**Chair: Steve Bagshaw**  
FUJIFILM Diosynth Biotechnologies

**Co-chair: Matthew Hancock MP**  
BIS Ministerial Representative

**Andrew Burgess**  
AzkoNobel

**David Hayward**  
AstraZeneca

**Stewart Davies**  
Augean plc

**Celia Caulcott**  
BBSRC

**Stuart West**  
Biocatalyst Ltd

**Mark Turner**  
BIS

**Alan Shaw**  
CALYSTA Energy

**Steve Elliott**  
Chemical Industries Association

**Sandy Dobbie**  
Chemical Sciences Scotland

**Jcanna Woolf**  
Cogent

**Nigel Perry, Colin Harrison**  
CPI

**Keith Layden**  
Croda

**David Chaplin**  
Dr Reddy's, Chirotech

**Jonathon Porritt**  
Forum for the Future

**Edward Green**  
Green Biologics

**David Brown**  
IChemE

**Ian Fotheringham**  
Ingenza

**David Wright**  
Innovate UK

**Yvonne Armitage**  
(*Colin Tattam & Rebecca Wood*  
*secretariat*)  
KTN

**Will Barton**  
Oxford Biotrans

**Paul Booth**  
SABIC UK Petrochemicals

**Iain Wilcock**  
Seventure

**Jeremy Shears**  
Shell

**David Lawrence**  
Syngenta

**Andrew Hagan**  
World Economic Forum

## Driving Change - Connecting it all together

One of the early conclusions of the IB-IGT IB2025 report was that in IB, a significant communication and strategy gap existed between existing and new upstream and downstream supply chains. This led the IB-IGT to conclude, "*Companies and centres developing IB products and processes, and the chemistry-using industries that will generate the rewards of IB, are not well connected in the UK*". Despite many years of profitable production of fine and specialty chemicals through IB processes, the lack of a coherent strategy meant that at the time of the IB2025 report, a disconnect had developed between the market knowledge and technology expertise.

Recommendations **one** and **two** from IB2025 focused on the need for better connections and coherence across the IB sector - this was the environment under which the IBLF was established in October 2009. With Ian Shott installed as the founding Chairman and with ministerial co-chair from BIS through the Minister of State for Business and Enterprise, the Forum was tasked to take ownership of the recommendations from IB2025 and to provide a coherent voice across industry, academia and Government through identified key individuals. The IBLF continues to bring together influential industrial leaders and various stakeholders to deliver the recommendations of the IB-IGT, and ensure alignment of the needs and expectations of the sector.

Assuming responsibility to improve connectivity and awareness of the IB opportunity for the UK, the IBLF has supported and delivered a number of activities over the past years including:

- Delivery of a series of 1-day thematic events culminating in the 'Leading IB: A UK Showcase' 2-day event in January 2013 bringing together nearly 300 delegates across industry, academia and public sector.

This event demonstrated progress in IB uptake, and provided the platform to set-out next steps, including an announcement by David Willetts MP that £63m would be invested by Government in coordinated networks and research and innovation funding (BBSRC £37m, Innovate UK £15m, EPSRC £11m).

- Highlighting the importance of IB as a manufacturing technology through an exhibition in the public foyer of BIS (1 Victoria Street, London) in August 2013. IBLF members FUJIFILM Diosynth Biotechnologies, Croda and the Centre for Process Innovation provided exhibits, and Biome Technologies and Bouygues showed the role of IB in the manufacture of pharmaceuticals, cosmetics, food additives and plastics. Michael Fallon MP (and then co-chair of the IBLF) attended the exhibition, along with David Willetts MP.

- Coordination of European (European Forum of Industrial Biotechnology) and UK (KTN and IChemE) events on IB over a 1-week period in Edinburgh in October 2010.

The IBLF has also led the way in connecting UK organisations with interest across a broader biotechnology scope. In 2014, a working relationship was established between the industrial co-chairs of the IBLF, the Synthetic Biology Leadership Council (SBLC), and Agri-Technology Leadership Council (ATLC). Together, Steve Bagshaw (IBLF), Lionel Clarke (SBLC) and Judith Batchelar (ATLC) identified the need for a coordinated definition of a UK bioeconomy, and communication material has subsequently been developed with Government and a number of other key stakeholders.

Building on the IB2025 report, the IBLF also oversaw the identification of priority areas of largest opportunity for the UK to reach the

identified £12bn of potential sales value in the IB sector by the year 2025:

- UK Plc becomes a leading centre of competence in fine and speciality chemicals;
- Increased uptake of biocatalysis and fermentation in the existing UK chemicals industry;
- UK becomes a top three producer of high value chemicals in plants;
- UK becomes a leading source of know-how in producing commodity and intermediate chemicals through biocatalysis and fermentation.

In December 2012, the IBLF undertook a survey of UK companies and estimated the value of IB to the UK had increased from £1.8bn in 2008 to £4.5bn, demonstrating clear progress in the three years since the publication of the IB2025 report. Recognising the need to capitalise on this momentum shift, the IBLF agreed to extend its original remit to meet for a further 6 meetings, with Steve Bagshaw (CEO, Fujifilm Diosynth Biotechnologies) assuming the role of Chairman from January 2013. The second economic impact study is currently underway.

It is now widely recognised that since its inception five years ago, the IBLF has overseen the progress and delivery of each of the recommended themes from the IB-IGT. The IBLF recognises that the UK is on track to achieve the predicted £12bn of value by 2025, but that this has not yet been reached, and further coordinated leadership is needed in order to propel the UK to become a world leader in the area by 2025. In particular, the future must focus on supporting and nurturing the commercialisation of IB products, processes and start-up companies, whilst recognising the need to include IB for biofuels, bioenergy, pharmaceuticals and waste feedstocks in its revised remit.

### TIMELINE

2009 - 14



## Delivering Change – Facilities and Funding

When it comes to 'Delivering Change', IB2025 focused on de-risking access to new products and technologies. This particular theme highlighted several key factors in the perception of risk in innovation, including scale. For example, it was found that some large enterprises are prepared to take a risk and invest in assets required for development projects. However, others, inclusive of both large and small companies, delay investment until technical risks have been reduced. SMEs also find it difficult to develop and acquire the necessary assets to pursue their innovation pipeline, and can face significant barriers to entry due to the limited availability of equipment and expertise on how to use it. Another key challenge identified included the gaps that exist in processing at scale, both upstream and downstream.

Now, five years on from the publication of IB2025, significant progress has been made with regards to the recommendations that focus on delivering change – namely **three, four and five**. One of the specific

recommendations included development of an open access fermentation demonstrator facility.

Following £12m investment from BIS, the expansion of CPI's National Industrial Biotechnology Facility was officially opened in May 2011, on time and in budget, just 10 months following the initial 'breaking ground' on the project. The open access facilities include upstream biomass processing, 10,000-litre fermentation capacity and enhanced downstream processing. From 2011, the IB facilities at CPI have been utilised by 65 companies including 32 SMEs and 11 state/academic institutions, many of whom have become repeat and/or regular customers. A number of these projects have also been enabled through the use of Innovate UK's High Value Chemicals through Industrial Biotechnology funding competitions as described below, further derisking the IB project investment. CPI assets, and more importantly their knowledge capability to guide companies through

the lab to commercial scale process, has been critical in the progress made by UK companies in exploiting the potential of IB for chemical manufacture since 2009.

Subsequently, further UK Government investments into open access demonstration scale facilities for products and processes of IB have included:

- £2.5m capital grant from BIS, and the European Regional Development Fund (ERDF), added to a further £1m from the University of York, to open the Biorenewables Development Centre (BDC) offering:
  - o feedstock development & molecular analysis
  - o processing & pre-processing
  - o microbiology and anaerobic digestion
- BBSRC invested £1.5m in equipment, awarded across the five Knowledge-Based Bio-Economy Strategic Longer and Larger grants (sLoLa) in 2012.

## Case Study: Fiberight and CPI collaborate to develop capabilities to valorise municipal solid waste (MSW)

US based clean technology company, Fiberight, has developed a low capital cost, 'whole' process solution to valorise all components within MSW, in particular the problematic waste biomass fraction by application of industrial biotechnology. Fiberight specialise in the extraction of cellulosic fibres from a wide range of post consumer wastes for use in higher value products. Using enzymes, they have developed a process to efficiently convert the cellulose to value added sugars, the main feedstock for bio-processing to higher value products.

The Centre for Process Innovation (CPI) has formed a strategic partnership with Fiberight to champion the development of this technology platform with the intention of commercialisation in the UK and Europe. Fiberight has utilised CPI's integrated business support services to transfer their research capability to the UK. The platform aims to be energy self-sufficient and all value from the clean recycles within waste will be exploited. This programme has attracted further collaboration with major end-user supply chains in UK chemical and manufacturing industries.

An investment of £2.5bn would process all 9 million tonnes of household waste currently disposed of to landfill every year and this would generate over 4,200 jobs, 510K tonnes of value added sugar feedstock and 140K tonnes of energy rich methane gas for UK-IB. In addition, the process captures over 300K tonnes of carbon dioxide and produces 1 million tonnes of lignin-rich biomass (a prepared fuel for gasification), which can be used as feedstock for C1/syngas fermentation, as part of a wider bio-refinery activity.

Recommendations **four** and **five** focused on the delivery of strategic funds. This included both broadening the remit of existing demonstration funds, and providing access to IB-related funding for SMEs. In response to this, Innovate UK, with support from BBSRC and EPSRC, funded five annual calls up to £2.5m in the dedicated area of High Value Chemicals through Industrial Biotechnology (HVC-IB) to support innovation projects from feasibility to demonstration. In addition, in response to recommendation **sixteen** these funding calls specifically suggested the use of the CCaLC (Carbon Calculations over the Life Cycle of Industrial Activities) tool to calculate the IB product or process' carbon footprint, and where feasible, demonstrate

potential CO<sub>2</sub> savings or environmental benefits. The resulting outputs of these calls ensured in excess of 100 projects were funded over the past 5 years, leveraging funds totalling £10m involving 47 discrete companies:

- HVC 1 (2009-2010), £2.5m, 19 feasibility projects
- HVC 2 (2010-2011), £2.3m, 10 feasibility and 4 cR&D projects
- HVC 3 (2011-2012), £1.9m, 5 feasibility and 4 cR&D projects
- HVC 4 (2012-2014), £2.1m, 3 business models, 10 feasibility and 2 cR&D projects

- HVC 5 (2013-2014), £2.5m, 10 feasibility and 3 cR&D projects.

Over the five year period, the Centre for Process Innovation was asked to contribute as project partners in 15 projects demonstrating utilisation of the facilities as envisioned. In addition, a review of the feasibility projects funded in the first year showed a 3 year revenue value of £16m with 48 jobs created or saved and 19 patent applications.

## Case Study: Lucite take Innovate pathway to lower production costs

As the largest producer of methacrylates in the world, Lucite International UK Ltd is pioneering attempts to meet demand for greener production of these polymer molecules. As they approach the halfway point of a 10 year research programme, the company's Research Associate David Johnson reflects on support provided by Innovate UK funding and the partnerships enabled with UK SMEs that are starting to bear fruit.

**"Even before the market pressure for bio-derived materials had really started to gain**

**momentum, we were working to determine the lowest cost routes to production through PhD programmes with EPSRC and BBSRC,"** says David. **"However it was soon evident that though the routes available were workable in a practical sense, the resulting industrial process remained commercially uncompetitive."**

Fortunately David and his colleagues persevered, supporting their own investigation into the engineering challenges, by collaborating with UK SME Ingenza to look at optimising the underlying

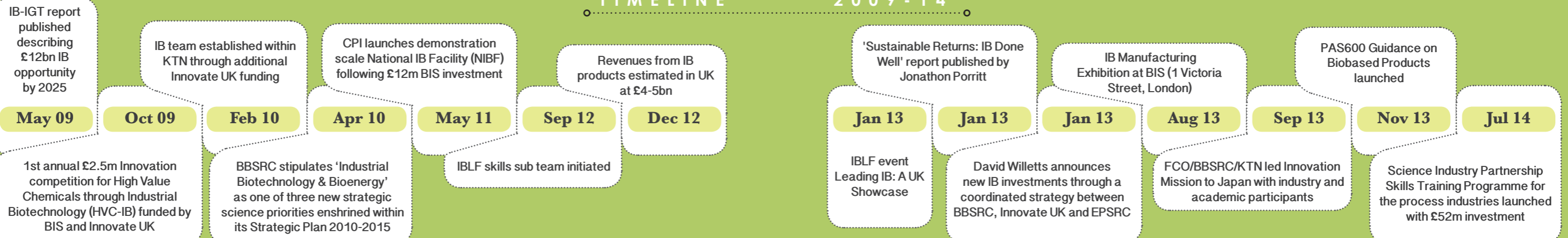
biochemistry. **"We quickly realised there was more work to do than could be financed by us alone, so Ingenza pointed us towards new calls from Innovate UK which matched up well and allowed us to supplement our funding with additional investment."**

The resulting project has delivered a deeper understanding of both the biochemistry and the process engineering. **"The funding has helped an awful lot to start to narrow down the processes with the potential to be economically viable."**



### TIMELINE

2009 - 14



In addition, a private finance sub-team set out to identify the barriers to private finance for IB start-ups and how these could be lowered and/or removed. The team made a number of high-level recommendations for attracting capital from the private sector:

- Attract more risk capital:
  - o Novel shared risk business models (de-risk propositions – partnerships, purchase contracts)
  - o Enhance IB investment returns (grants, access to matched funding, tax)
  - o Novel fund structures e.g. LSP Health-economic fund, Burrell's Malaysia Fund, Innovation Ireland LP fund

o New sources of IB funding e.g. corporates, Hermes/EIF, Sovereign (inward)

- Improve IB information sources, technical skills and collaboration in UK:
  - o Increase corporate engagement – with potential new roles for BIS and/or UKTI in support of the BioIndustry Association (BIA). Potential investors need to understand the industry players viewpoint and be able to showcase new technologies
  - o Facilitate access for UK SMEs to relevant markets e.g. BRIC and Asian
  - o Identify and enhance due diligence resources - at present, it is difficult to

evaluate the potential techno-economic advantage of a new IB technology.

The Green Investment Bank was created by the UK Government in 2012 and has committed to provide an initial £3.8bn of capital to invest in green projects, on commercial terms, across the UK and mobilise other private sector capital into the UK's green economy. The purpose of which is to help fund the creation of new, modern, green infrastructure across the UK and is therefore inclusive of industrial biotechnology.

## Case Study: Private investment converts Green Biologics' ambitions to operational reality

Starting out a decade ago as a research contractor, Oxford's Green Biologics is today well on the way to becoming one of the world's leading suppliers of advanced fermentation technologies for the production of renewable chemicals. The company focuses on biobutanol, which is a valuable precursor for many polymers, plastics and household products such as paints.

Contract research was an important stepping stone towards a longer term strategy focused on the production of cost-competitive biobutanol via microbial fermentation and meeting the company founder Dr Edward

Green's ambition to own and operate a commercial fermentation facility. Revenues from contract research were bolstered by a series of investments from friends, family, business angels and local venture capitalists. In 2013, a further \$25m was raised for process scale-up from European VCs and a corporate investor.

Green Biologics operates a capital efficient business model capitalising on existing ethanol fermentation assets for both demonstration and commercialisation. By the end of 2014, the company had completed successful demonstration of its advanced

butanol fermentation process in Iowa and acquired a commercial starch ethanol plant in Minnesota. Funding has now been secured to convert the commercial facility to produce butanol.

**"Whilst investor appetite for new IB technologies is strong,"** says Dr Green, **"an early history of unfilled promise in IB means credibility and a track record of delivering on investment is highly valued. The UK Government's support has played a big part in helping our private funding go further and building confidence within the VC community."**



## Delivering Change – Innovation and Knowledge Transfer

Theme **three** of IB2025 included six key recommendations (**six to eleven**) focused on 'Delivering Change through Innovation & Knowledge Transfer'. Long-term R&D funding and a critical mass are needed to underpin any developing technology, not just IB. IB2025 recognised a need for the UK's existing IB centres of expertise to be extended, supported and coordinated, and for business support schemes and organisations to provide a stable, expert pathway for the development and commercialisation of IB opportunities across the UK.

The key public funding bodies instrumental in delivering this strategic change and innovation in IB within the UK are BBSRC, EPSRC and Innovate UK. Innovate UK has supported innovation and knowledge transfer for IB since 2009, initially through their

Biosciences strategy (2009-2012) and later in High Value Manufacturing (2012-2015), ensuring support for innovative projects from enabling science through to industrial application and demonstration. BBSRC established a strategic science priority in industrial biotechnology and bioenergy and created the IB Strategy Advisory Panel, both of which have resulted in the Council investing (with Innovate UK and EPSRC) over £100m in new IB research since 2012. A significant proportion of this research is conducted in collaboration with industrial partners.

Prior to the development of its IB Strategy, BBSRC invested in the IB area by pioneering the innovative concept of the Research Industry Club in the form of the Bioprocessing Research Industry Club (BRIC) and the Integrated Biorefining

Research and Technology Industry (IBTI) Club. These programmes resulted in excess of 60 new projects with over £30m investment. Since then, BBSRC has extended its reach with its strategic Longer, Larger (sLoLa) grant awards, which funded 11 projects at an average of £3m each. Alongside this, in 2012 EPSRC invested £15m in 6 projects focused on Sustainable Chemical Feedstocks and supported relevant Doctoral Training Centres (DTCs) at the University of Newcastle and University College London.

In 2012/13, BBSRC teamed up with EPSRC to establish a range of Networks in Industrial Biotechnology and Bioenergy. These subsequently became known as BBSRC NIBB, with 13 networks (two co-funded by EPSRC) receiving a total funding commitment of £18m in late 2013.



### TIMELINE

2009 - 14

IB-IGT report published describing £12bn IB opportunity by 2025

May 09

1st annual £2.5m Innovation competition for High Value Chemicals through Industrial Biotechnology (HVC-IB) funded by BIS and Innovate UK

IB team established within KTN through additional Innovate UK funding

Oct 09

Feb 10

BBSRC stipulates 'Industrial Biotechnology & Bioenergy' as one of three new strategic science priorities enshrined within its Strategic Plan 2010-2015

CPI launches demonstration scale National IB Facility (NIBF) following £12m BIS investment

Apr 10

May 11

IBLF skills sub team initiated

Revenues from IB products estimated in UK at £4-5bn

Sep 12

Dec 12

'Sustainable Returns: IB Done Well' report published by Jonathon Porritt

Jan 13

IBLF event Leading IB: A UK Showcase

Jan 13

David Willetts announces new IB investments through a coordinated strategy between BBSRC, Innovate UK and EPSRC

IB Manufacturing Exhibition at BIS (1 Victoria Street, London)

Jan 13

FCO/BBSRC/KTN led Innovation Mission to Japan with industry and academic participants

Aug 13

PAS600 Guidance on Biobased Products launched

Sep 13

Nov 13

Science Industry Partnership Skills Training Programme for the process industries launched with £52m investment

Jul 14

# BBSRC NIBB

**ADNet: Anaerobic Digestion Network**



**Biocatnet: Network in Biocatalyst Discovery, Development and Scale-Up**



**BioProNET: Bioprocessing Network: BioProNET**



**C1NET: Chemicals from C1 Gas**



**CBMNet: Crossing Biological Membranes**



**FoodWasteNet: Food Processing Waste and By-Products Utilisation Network**



**HVCfP: High Value Chemicals from Plants Network**



**IBCarb: Glycoscience Tools for Biotechnology and Bioenergy**



**LBNet: Lignocellulosic Biorefinery Network**



**Metals in Biology: The Elements of Biotechnology and Bioenergy**



**NPRONET: Natural Products Discovery and Bioengineering Network**



**PHYCONET: Unlocking the IB Potential of Microalgae**



**P2P: A Network of Integrated Technologies: Plants to Products**



The launch of BBSRC NIBB coincided with the launch of the new IB Catalyst in Autumn 2013, administered by Innovate UK in partnership with BBSRC and EPSRC. The broad remit of the IB Catalyst ensures all areas highlighted in recommendations **six** and **seven** of IB2025 can be proposed by

both academic and industry-led consortia. By the end of March 2015, the IB Catalyst will have committed its first £45m (BBSRC - £20m, Innovate UK - £15m, EPSRC - £10m) funding through five different streams ranging from small-scale feasibility studies through to substantial translational projects.

The next phase of funding was announced in December 2014, with a further commitment of up to £40m in 2015/16 from the three funding bodies (BBSRC - £20m, EPSRC - £10m, Innovate UK - £10m).

## Case Study: Biome Bioplastics chose academic help to broaden IB product portfolio

With a team of 30 at their Southampton HQ, Biome Bioplastics have been part of the UK bio-based economy for many years, developing bioplastics from cornstarch, potato starch and cellulose for packaging, agriculture and horticulture.

However, a few years ago, Paul Mines, Biome Bioplastics' Chief Executive Officer, foresaw a need for support if bioplastics were ever to truly compete with oil based alternatives, available at half the price. "We needed a technological shift and that could

only come with help from the academic community."

Paul came across research in lignin derived chemicals, and in particular the work of Dr Tim Bugg at Warwick University. After meeting Tim, Paul identified 2-3 interesting classes of chemicals and won funding for a feasibility study that has already delivered good yields for various bioplastic precursors. The team are now looking at scaling up the fermentation production methods with support of researchers at the universities of

Leeds and Liverpool, as well as the Centre for Process Innovation.

Despite initial success, Biome Bioplastics is still open to other approaches. Biome Bioplastics recently put in a funding application with a contact made at UCL through the BBSRC NIBB to investigate creating bioplastics from organic food waste.

"In two years we have gone from minimal academic interaction to working with 4 who are integral to our research strategy."



### TIMELINE

2009 - 14

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## Company Engagement

Through various funding mechanisms Innovate UK, BBSRC, EPSRC and the Scottish Funding Council (SFC) have enabled the exchange of knowledge between industry and the research base through extensive company engagement. Through funding from Innovate UK, the KTN has extensively engaged with companies directly to understand their needs, identify new opportunities and provide connection and steer to develop new collaborative projects, as requested under recommendation **eight** of IB2025. As a result of this effort:

- The 13 BBSRC NIBB are currently engaging at least 230 different companies and this is growing almost weekly. Several companies have joined multiple networks, with companies like Croda, GSK and Green Biologics joining 9, 7 and 5 different BBSRC NIBB respectively.

- The dedicated IB team at the KTN, led by the IB sector expert Dr Yvonne Armitage (appointed in response to recommendation **ten**), has now directly met with in excess of 170 companies, and this continues to rise. Supporting and tracking company engagement following the visits has resulted in excess of 70 new projects being initiated and 6 new privately financed business-to-business strategic research partnerships formed.

- In January 2013, 'Leading IB: A UK Showcase' welcomed nearly 300 industry leaders, technology providers and a wide range of other stakeholders from multiple sectors to share details of industrial biotechnology innovation over two days.

- In January 2014, the SFC announced an investment of £10m in the Industrial Biotechnology Innovation Centre (IBioIC), which is expected to leverage a further investment of £45m over the next five years through industrial member contributions and external funding agencies. The industry-led IBioIC brings together 14 higher education institutes to create a single portal for industry to connect with IB leaders in academia in Scotland.

## Case Study: Chemoxy find the benefits are mutual in collaboration with Biocatalysts Ltd

Chemoxy is one of Europe's largest providers of chemical manufacturing services with customers across the petrochemical and speciality chemical sectors.

Interest in the possible use of IB processes led to the attendance of the company's R&D Manager, David Randall, at an IBLF event on biocatalysis where they met Biocatalysts Ltd, a manufacturer of innovative catalysts. With input from Northumbria University, the two businesses identified a mutually beneficial opportunity - investigating the biotransformation of a waste stream to produce valuable organic chemicals for use in the production of surface coatings.

The collaboration has been progressing well with Chemoxy interested in the

biotransformation of the material, and Biocatalysts focused on producing catalysts in sufficient quantities to make the process economically viable.

**"If everything works out, we would create our own mini supply chain,"** says David. **"We would get the feedstock, they would produce the enzyme, and we would do the chemistry."**

The results are starting to come to fruition. **"We have already seen some very highly active catalysts produced. They are not quite achieving the target conversion so this is where we are focusing now - improving the yield. It's a very exciting time!"**



## International Activities

To support the knowledge transfer from and to the UK with overseas companies and organisations, a number of initiatives have been initiated and delivered by a number of the IBLF partners.

Since 2009 the KTN has secured a seat on the IB Council of EuropaBio (the European Association for Bioindustries), which aims to create a more positive environment in Europe within which biotech industries can flourish. This has enabled the KTN to promote the activity of the IBLF to the broader EU community and ensure the UK's priorities and interests are represented, as well as to help shape and influence EU funding

policy related to IB. In 2013 the Foreign and Commonwealth Office financed a mission to Japan, in partnership with UK Trade & Investment (UKTI), BBSRC and KTN, to build new potential academic and business partnerships.

Most significantly in international activity, in February 2011, Innovate UK signed a five-year Memorandum of Understanding (MoU) with Innovation Norway to jointly identify and capitalise on opportunities and synergies in IB and biorefining. Bilateral collaborations have been stimulated through 37 events, such as knowledge exchange tours and symposia, and 11 co-funded projects that have been supported by the KTN.

A total investment of £3.4m by the UK and Norway in collaborative projects is on course to deliver over £100m in return through the development of a variety of new or significantly improved products, services and processes, new patent applications, and the creation of new jobs.

In less than four years, the MoU has been responsible for 8 new products/services with three currently launched to the market, as well as 6 patents, and 7 more pending. 27 jobs have also been created, with a further 10 safeguarded over the next 5 years.

## Case Study: Producing high value cosmetic ingredients from microalgae

GlycoMar Limited, a Scotland based biotechnology company, and MicroA AS, a microalgae and photobioreactor technology company based in Norway, were introduced by the KTN and Innovation Norway (IN).

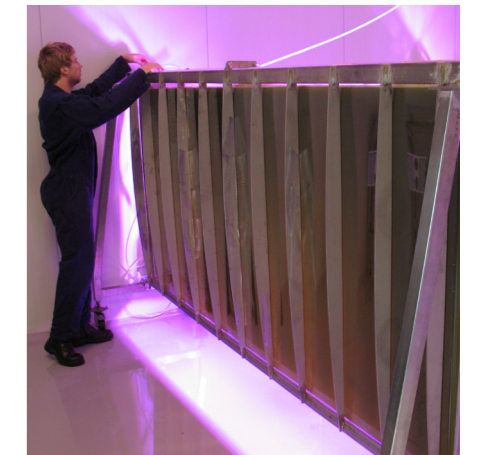
They submitted a successful project proposal to an Innovate UK and IN funded competition for industrial biotechnology in 2011. The pilot study created a scaled down version of a full production line for producing bioactive polysaccharides synthesized by microalgae, and explored opportunities for sustainable, high quality, and high volume production.

A techno-economic assessment of the trial data was very encouraging, and the partners are now moving towards commercialisation of a high value skincare ingredient derived from a marine microalga.

The partners went on to obtain EuroStars funding for a demonstration scale study and in 2014, a grant from IBioIC.

This collaboration resulted in a new product, a high value natural skin care ingredient, with an estimated market potential of £5-20m. The product is expected to launch in 2-3 years.

**"Glycomar developed background product IP but didn't have a production capability, so it was an obvious fit to work with MicroA who have production IP relevant to our product. The collaboration was made easier by accessing grant support from Innovate UK and from Eurostars"** says Charlie Bavington, MD, Glycomar Ltd.



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## Enabling Change - Skills

The UK is globally renowned for its excellence in life sciences, chemistry and engineering technical capabilities, and both industry and academia benefit from the capability of graduates from UK universities. However, the 2009 IB2025 report highlighted a shortage of graduates with the relevant skills that would allow them to step into an IB role. Recommendations **twelve to fourteen** in theme **four** focused on how the UK can be successful in exploiting IB – this included identifying the need for a highly skilled workforce, not only in the traditional disciplines of chemistry and engineering, but also combining biochemistry, enzymology, fermentation, and some of the newer areas of molecular biology, metabolic and protein engineering and bioinformatics.

### Mind the academia gap

As universities recognised the need for graduates with multidisciplinary skills, EPSRC funded Centres for Doctoral Training (CDTs) in various subjects including Bioprocessing Engineering, Sustainable Chemical Technologies and Systems Biology. In addition, BBSRC funds Doctoral Training Partnerships (DTPs) in Industrial Biotechnology and Bioenergy, which are available to students at a variety of universities. Both these schemes aim to deliver a wide range of technical and transferable skills to students, to enhance their capability and therefore providing a highly skilled workforce for both academia and industry.

As an enabling technology that is highly multidisciplinary, the provision of a Masters course, as well as short practical training modules in specifics such as fermentation techniques, were also developed to address gaps in skills.

In 2010, the Institution of Chemical Engineers (IChemE) carried out a review of MSc provision in the UK on behalf of the IBLF. The

survey included a list of current providers of IB-related Master's programmes and an analysis of skills offered, industry demand, and gaps. The survey showed that in 2009-10, approximately 700 places were available on 35 IB related courses. Industrial placements were found to be in decline and so the IChemE recommended that employers should directly promote IB as a career option. Another key recommendation was to increase access incentives such as grants for students. The Scottish-based Industrial Biotechnology Innovation Centre (IBIoC) has responded to the need for an MSc Course in IB, and the first cohort of students enrolled in 2014. This includes modules in an introduction to IB, systems and synthetic biology, and bioprocess engineering, to name a few.

In 2011, together with their delivery partner the National Skills Academy for the Process Industries (NSAPI), Cogent set up a working group that included industry members from the chemical, energy and biopharma sectors. Its aim was to investigate the skills needs for IB-using companies. The mixture of backgrounds and capabilities of the group's members ensured that best practice and lessons learnt in more established areas could be utilised to speed up the skills development for the newer users of IB.

### In-service learning

Through the work of Cogent's group, it was established that the skills gap extended beyond high-quality graduates and post-graduates. The need for skilled technicians and plant/process operators to exploit advances in IB gave rise to a nationally recognised 'Gold Standard' award launched for Process Technician in Biotechnology. Short courses such as An Introduction to Microbiology, Aseptic Awareness and Fermentation were also developed in conjunction with CPI.

In 2012, the Cogent Working Group came together with the IBLF and the professional bodies of IChemE, the Royal Society of Chemistry and the Society of Biology, to incorporate higher level qualifications, training for leaders in IB companies, and possible professional accreditation into their plans.

The latest exciting development in this area has been the launch of a Science Industry Partnership (SIP) for the process industries (July 2014). This initiative has seen a commitment from Government of £32.6m together with £20m from industry partners to address the shortage of skilled employees across the industries in recent years. The SIP is led by GSK, and has approximately 100 companies signed up. Much of the money will support apprenticeships and higher apprenticeships.

As part of the SIP, a potential Advanced Training Partnership (ATP) is being considered, modelled on the ATP in agriculture and food funded by BBSRC. ATPs are an effective combination of postgraduate training offered by HEIs, but guided by industry in terms of demand, and therefore offering business-required, research-led training. A recent survey funded by the SIP was carried out by Trends Business Research, on behalf of Cogent and BBSRC, to look at whether there is a real industrial demand for an IB ATP and to identify any perceived skills gap.

It is clear that significant progress has been made in addressing the skills shortage and gaps identified by IB-using companies. But in order to ensure the UK remains a leader in producing a highly skilled workforce, this should be viewed as an on-going review of skills. As technology continues to progress, there is also a need for employees at all levels to be flexible and adaptable to new ideas.

## Case Study: Biocatalysts

Biocatalysts Ltd's customised enzymes are used by big companies across the food and pharmaceuticals sectors. Year upon year of steady growth, founded on the introduction of new skills and capability, has seen the Cardiff based company achieve a market leading position globally.

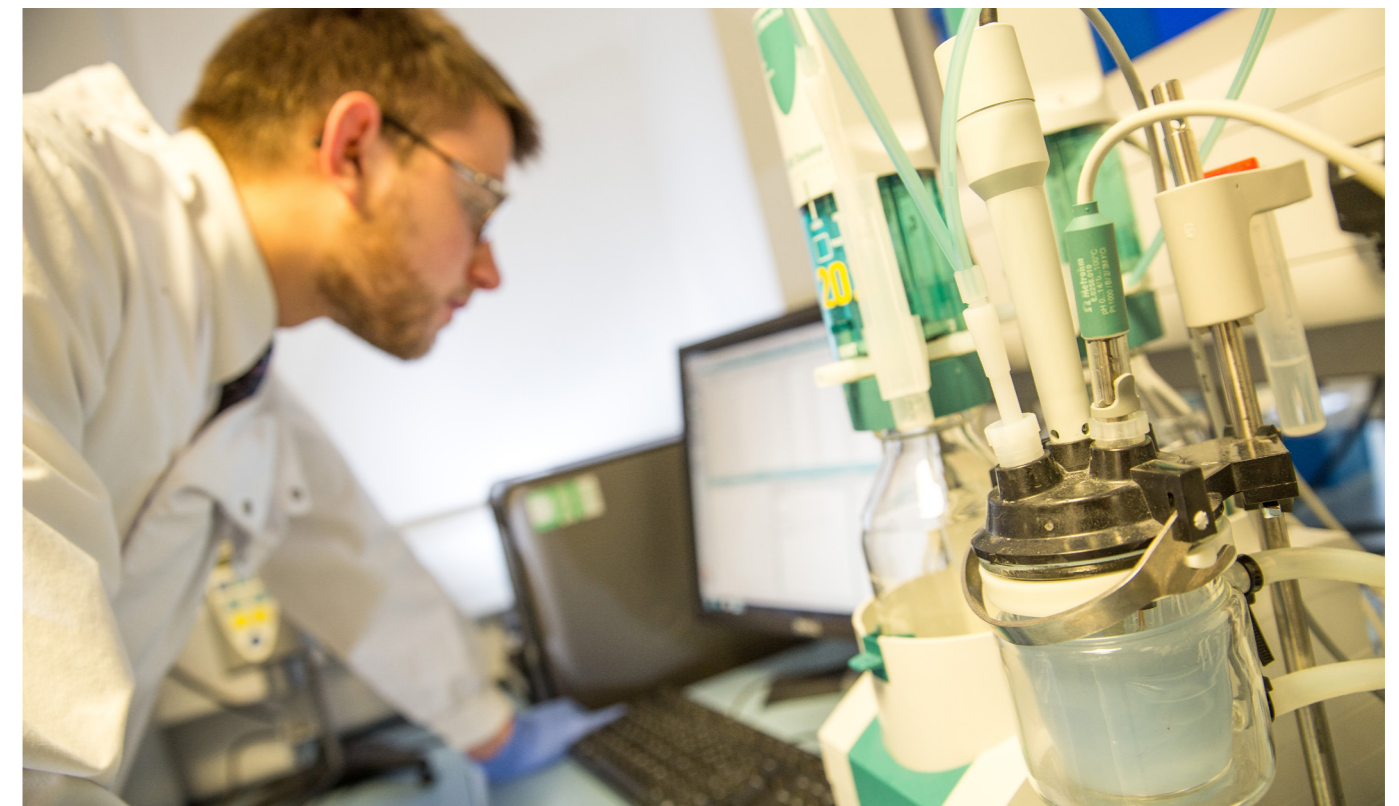
**"In a relatively specialist area like IB - being able to access new expertise, and incorporate and develop it internally has been vital in building our knowledge base and expanding our capabilities,"** says Managing Director Stuart West.

As well as an extensive recruitment and personal development programme, with five new scientific apprentices joining in the last year alone, Biocatalysts has been able to access unique expertise and equipment within the academic sector - collaborations supported by both Innovate UK and Research Council funded projects.

Here a history of successful work with the Universities of Bath and Nottingham, taking on PhDs through the Government backed Knowledge Transfer Partnerships (KTPs), has recently expanded to incorporate close

to 10 institutions via BBSRC NIBB and CASE awards. The introduction of unique academic expertise is revolutionising Biocatalysts' production techniques, making them faster and more effective.

**"What we can do now, creating a new enzyme from scratch in just a few weeks, would have seemed like science fiction only a few years ago,"** adds Stuart.



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## Enabling Change - Perception and Awareness

In order to enable real change in the IB sector, the IB-IGT report identified seven recommendations (**fifteen to twenty one**) that together aim to create a supportive 'public' and 'business' environment for IB in the UK. IB2025 stated that *'public perception and expectations have great significance in determining whether IB advances at the necessary pace and scale to deliver its many benefits'*. Similarly, a Sciencewise study commissioned for the IB-IGT report found the main barrier to public acceptance of IB to be a lack of knowledge or understanding of new technologies. In response, the IB-IGT identified four areas where coherent leadership could provide the greatest impact on improving perception and awareness of IB.

### Communicating IB and the bioeconomy

IBLF members identified that the language used in communicating the benefits of IB and its potential in the UK is not yet clear. This presents a risk that the media, and therefore the public, will become sceptical about its benefits, presenting a possible barrier to uptake. A consistent language around industrial biotechnology, coupled with examples of benefits to society, need to be developed and better communicated if the UK is to realise the value that the effective utilisation of IB can bring. As a result, an IB Ambassadors workshop was held in 2014, bringing together key individuals from across the different communities, industry, Government, academia, and trade press, to develop a consistent set of messages on the benefits of IB.

Concurrently the connection of the IBLF, SBLC and ATLC industrial chairs (as described on page 5) has highlighted the need for a consistent definition and messages for the UK on the potential of a bioeconomy. In late 2014, BBSRC worked in partnership with the KTN's IB team to harness stakeholder views on a working definition for the bioeconomy

and a set of communications messages for the three industrial Chairs to use, initially for an audience of Ministers and policymakers. Definitions and messages are now in place and presented in a set of communications materials, which feature infographics for the bioeconomy and a series of case studies in the three areas represented by the IBLF, SBLC and ATLC.

### Public perception of IB

Jonathon Porritt, (Founder of Forum for the Future) was appointed Chair of a Stakeholder Council that included retailers and NGOs. As a result, a report was produced examining what 'IB Done Well' might look like from a sustainability perspective. In January 2013, 'Sustainable Returns: IB Done Well' was published highlighting the huge potential for IB in the UK, but also recognising the significant barriers from a public, policy and investor perspective. Key issues in the debate around IB include biofuels, land use, GM, transparency and regulation, and in the report, Porritt set out a list of policy and industry mandates for consideration if businesses are to "Do IB Well". Engagement with NGOs has continued in 2014 to identify the specifics of the key issues and ways in which collaboration with NGOs is appropriate and of value.

### Standards

As in all emerging sectors, standards and certifications can help to define a market for products. At this time, this is especially true for bio-based products. Standards can ensure that environmental declarations are identified and that they are also based on objective evidence. Importantly, standards act as a 'rubber stamp', which then enable customers to make an informed choice.

In 2013, BIS sponsored the development of a new Publicly Available Specification (PAS) guidance document, which was facilitated by BSI Standards Limited and authored by the

Adapt Low Carbon Group at the University of East Anglia.

PAS 600 came into effect in November 2013, and it provides a signpost to key standards, codes of practice and guidance that can be adopted in the production, use and disposal phases of bio-based products. This guidance document also provides some steer on how best to communicate the benefits of bio-based products in a way that is accurate, verifiable, relevant and not misleading. It covers:

- Standards relevant to the life cycle of a product;
- Product labelling;
- Future areas which require standards development;
- Existing and potential future regulatory impacts.

Standards coverage is limited to the UK and EN/ISO standards, where adopted by the UK.

### Government policy and incentives

As part of an EU FP7 funded project, BIO-TIC, the KTN organised a UK and Ireland regional workshop identifying the barriers to IB across the EU, which was hosted by BIS. Part of the workshop specifically focused on the non-technological barriers including policy and legislation, and identified that many of the original IB-IGT hurdles such as 'sustainability certification', 'lack of public procurement' and a need to 'level the playing field' with regards to incentives for biofuels as well as bio-based products still needed to be overcome. This project is due to conclude in 2015 and will deliver a number of roadmaps for the EU to overcome the barriers to IB and make recommendations to the EU Commission. Once published the specific activity required within the UK should be reviewed and actioned.

To download PAS 600, visit: <http://shop.bsigroup.com/enProductDetail/?pid=00000000030262005>

## The Future of IB - Talking Heads



**Keith Layden**  
Chief Technology Officer, Croda

The IB sector in the UK is developing and improving, and we have begun to develop an international profile, but we are not yet global leaders. My hope is that with support, the IB sector here will continue to grow by responding to identified market needs - IB should be viewed as an enabling technology rather than one that is awaiting an application. For us at Croda, IB is an emerging part of our business that helps us to solve existing challenges in the personal care market – solutions that go far beyond those offered by traditional chemistry.

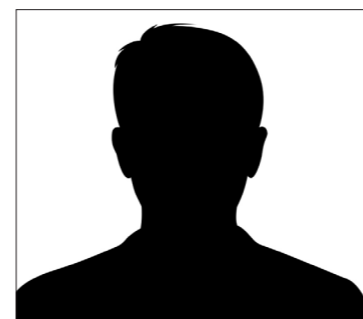
To position the UK at the forefront of IB, long-term strategic, innovative thinking will be needed at all levels. We will also need to focus on the skills agenda, to produce more multi-skilled, cross-disciplinary scientists. The Government has a role to play in this, as well as in de-risking development of IB technology, and encouraging its widespread adoption.



**Edward Green**  
Founder and Chief Scientific Advisor, Green Biologics

IB has a long heritage in the UK, with butanol fermentation commercialised here in 1912. And with environmental and economic drivers, coupled with technology advances, we have truly come full circle. Thanks to funding available from the Government and research councils, we are in a golden decade for industrial biotechnology research. The challenge now is to ensure that we can translate innovative, world-class science into commercial opportunities to ensure a sustainable IB industry in the UK.

The UK has some exciting opportunities in biocatalysis and in higher value chemical products. For commodity chemicals, the ability to extract and ferment sugars from wastes has tremendous potential. At Green Biologics we have developed a process to convert household waste into butanol, easing pressure on landfills. I believe that the UK will have a leading role in such waste conversion technologies in the coming decades. By focusing on waste feedstocks and higher value products, together with the support and development of new IB companies, the future looks bright.



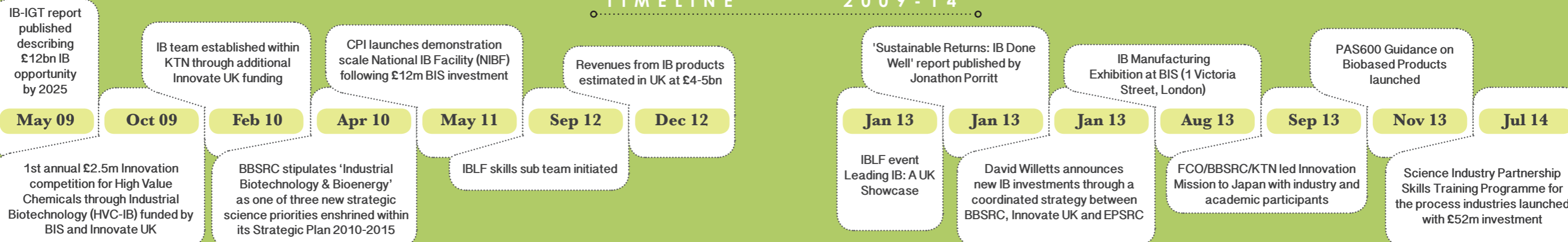
**Mark Turner**  
Head of the Chemicals Unit, Materials and Resource Industries, BIS

The UK Government is committed to supporting business-led growth of the chemistry-using industries to the economy by 50% in 2030, as set out in the Chemistry at Work strategy. Our ultimately finite traditional petrochemical feedstocks are becoming increasingly expensive, and we will need to seek sustainable alternatives for the future. There are significant opportunities for bio feedstocks to enable a growing bioeconomy, including from waste resources. So, in that challenging research landscape, organisations like the KTN have a key role to play in stimulating the market for these new processes and feedstocks. In particular, the IBLF is helping the UK to develop strategies for maximising the economic return from IB.

We need to capitalise on existing UK expertise and developments to ensure that we are leading the development of bio-based products and processes. Government working in partnership with industry through bodies like the IBLF will help to create the strategic developments that we need to realise these ambitions, and ensure that industrial biotechnology applications help UK businesses to remain competitive.

### TIMELINE

2009 - 14





**Joanna Woolf**  
Chief Executive Officer, Cogent

With a robust workforce at technical and business leader levels, and a recognised strength at the R&D level, the UK has a strong base to grow a globally competitive industrial biotechnology sector. In support, the infrastructure is being put in place to meet future demand for new skills. Through our collaboration with the Science Industry Partnership, Cogent is working with employers to optimise the pipeline of new talent for science sector workforces in areas with high growth potential like IB.

This includes the development of a university degree scheme to build-in practical industry relevant skills, and the creation of 1,500 apprentices and technicians across the sciences sector. There will be particular support for SME involvement in IB. The SIP's Strategy for the Science Industry will offer frameworks and £500 grants to guide skills development, whilst support for feasibility studies in proving and scaling up new technologies will come from the National Biologics Centre.



**Will Barton**  
Chairman, Oxford Biotrans Limited

There is certainly potential for major 'blockbuster' breakthroughs in various widely used chemically produced products, like the successful Goodyear "green tyre" containing polyisoprene derived from an IB process. The public has always appreciated more environmentally friendly products, though generally not enough to pay substantially more for them. However, with increasing raw material prices for many oil-derived chemicals, IB solutions are becoming more cost competitive, and this trend will likely continue over the next decade.

Through funding of Research Council and Innovate UK R&D programmes (e.g. the IB Catalyst), and the Catapult IB facility at CPI for developing and scaling up new production processes, the Government is supporting industry in de-risking the commercialisation of IB, not just as a route to greener operations, but to a more profitable approach to production. Through these initiatives, there is a sustained Government commitment that resonates well with industry.



**Nigel Perry**  
Chief Executive Officer, Centre for Process Innovation (CPI)

There is a huge amount of potential in industrial biotechnology; more than we realise. The early success of applications such as waste reprocessing and biologics reflects the growing maturity and understanding of what is possible, both technically and economically, in this exciting sector. The original drivers of demand generation - fossil fuel security and reducing our carbon footprint - are being joined by an increasing appreciation of bio-advantage and the fact that you can actually make more money than competitors working purely off fossil fuel based processes.

With the increasing relevance of these drivers the potential is here in the UK for a significant bio-derived, bio-enabled economy. The vision, consistency of purpose, and appropriate resources being provided from the very top within Government, is certainly removing the risks of future commercial investment. The result could see the UK become a very significant player indeed on the global stage.



**Merlin Goldman**  
Lead Technologist: High Value Manufacturing, Innovate UK

Industrial biotechnology presents opportunities for companies of all sizes to capitalise on increasing public and business demand for more sustainable routes to many of the products that they use, or produce, on a daily basis. At the top end there is huge potential growth in applications like the conversion of waste biomass (that doesn't include the edible parts of plants) and food waste into electricity of biofuels.

However, there is also room for smaller companies to flourish, producing lower volume, higher value products in sectors such as chemicals or pharmaceuticals. With less of a requirement for capital and infrastructure funds, these smaller companies benefit from smaller, flexible grants such as those provided by Innovate UK. We are currently in our 6th year of annual funding of IB-focused projects, during which we have funded over 100 projects with more than £10 million in public funds.



**Yvonne Armitage**  
Head of Industrial Biosciences & Biotechnology, KTN

In recent years, we have seen a step-change in the uptake of IB across the UK's chemistry-using industries. As many more companies recognise the economic, technical and environmental benefits of IB, they have begun to embrace the idea that IB truly applies to them.

Inspired by public funding support and improved market profile, companies from a wide range of sectors have realised that IB is an enabling technology that not only opens new markets, but also offers cost savings. The wide range of project ideas that the KTN has assisted with, from flavours to plastics and bulk chemicals to pharmaceutical intermediates, demonstrate the reach of the newly expanded IB landscape.

Sustained Government support has a role to play going forward. We must also identify our unique advantages, as well as leverage existing expertise through the coordinated efforts of the UK funding bodies in order to assure the UK's position as a global leader in IB.



**Ian Shott**  
Managing Partner, Shott Trinova & former Chair of the IBLF

There was a massive change for IB between the initial review in 2008 and the Showcase of 2013. We saw it move from a largely academic pursuit to a thriving sector with real products. I'm confident that we'll see continued progress at the 2015 Showcase because the biotech game has become more sophisticated and ever more substantial. In the US, three bio-refineries will produce over 100M gallons of military-grade transportation fuel, and in the UK, many traditional chemical companies have placed IB at the heart of their processes.

Thanks to collaborations enabled by major funding opportunities, we're beginning to see an IB explosion; a convergence of biology, chemistry, engineering, computational power and measurement. The horizon for IB has expanded substantially in terms of what people think can be achieved. The remaining challenge is a much-publicised one – the skills gap – and going forward, closing it will be a crucial part of developing the bioeconomy.



**Celia Caulcott**  
Executive Director, Innovation & Skills, BBSRC

In the last few years in the UK, we've put in place most of the things that will enable bioscience to transform the chemicals and processing industry, which will make them all industrial biotechnology. We have phenomenal science with internationally renowned scientists across the UK research base. Through programmes such as the IB Catalyst, there is now public intervention to support market failure. And there is real leadership in the sector, from the funding bodies, academia and the IBLF.

However, there are still two pieces missing from the IB jigsaw – one is a demonstrable pull from industry, strongly related to the absorptive capacity of the broader innovation landscape. Going hand-in-hand with this is the need for visible Government enthusiasm. To ensure industry engagement, a clear commitment from Government will be vital, as will addressing existing regulatory concerns. So, while there are significant challenges ahead, I strongly believe we can meet them and deliver a vibrant, transformed IB industry.

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## ANNEX 1: Recommendation Themes from IB2025

### Theme 1: Connecting it all together

#### • Recommendation 1:

The IB-IGT recommends that an overarching industry / Government Leadership Forum be established by Autumn 2009. This Forum would have ownership of the IB-IGT recommendations, power to oversee implementation, and responsibility for assessing and reviewing new ideas and opportunities.

#### • Recommendation 2:

The IB-IGT recommends that the leadership forum be responsible for raising awareness in the private and public sectors regarding the capabilities and potential of IB; as well as leading on the long-term development and promotion of IB into new and existing supply chains.

### Theme 2: Facilities and Funding

#### • Recommendation 3:

The IB-IGT recommends the development of an open access demonstrator facility, particularly for fermentation (up to 10 tonne capacity), with associated upstream and downstream facilities by 2010.

#### • Recommendation 4:

The IB-IGT recommends that an IB fund (of £2.5–5 million per year for 3–5 years) should be established by the end of 2009 to allow industry, particularly SMEs, access to demonstration facilities.

#### • Recommendation 5:

The IB-IGT recommends that the Government should improve access to demonstration funds by broadening the remit of existing commercial-scale demonstration funds to ensure that IB is included within the scope of eligible technologies.

### Theme 3: Innovation and Knowledge Transfer

#### • Recommendation 6:

The IB-IGT recommends that Innovate UK, EPSRC and BBSRC work together to support a single, virtual, centre of excellence in IB research and development that will capitalise on, and augment, existing academic centres where biologists, biotechnologists, chemists, chemical engineers and other relevant disciplines are co-located.

#### • Recommendation 7:

Innovate UK, EPSRC and BBSRC should work together through joint calls to ensure that the UK's world leading science base in genomics fermentation, biocatalysis, plant science, marine organisms and mycology is effectively developed and translated into IB applications.

#### • Recommendation 8:

The IB-IGT recommends that the availability and uptake of general business support schemes is facilitated by providing a single point of contact, by the end of 2009, which can give clearer signposting to schemes relevant to IB companies.

#### • Recommendation 9:

The IB-IGT recommends that the scope of any new business support schemes should be defined in a way that does not exclude or impede IB, and that existing funding schemes that may unintentionally exclude or marginalise IB be modified to remove this blockage.

#### • Recommendation 10:

The IB-IGT recommends that a 'sector expert' be based within the IB Leadership Forum.

#### • Recommendation 11:

The IB-IGT recommends that UKTI, in conjunction with the IB Leadership Forum, undertake a coordinated approach to promoting UK IB capability and infrastructure overseas from 2010 onwards.

### Theme 4: Skills

#### • Recommendation 12:

The IB-IGT recommends that the Research Councils, EPSRC and BBSRC, the professional institutions in chemical engineering, chemistry and biology, the Sector Skills Councils, SEMTA and Cogent, should continue to work together to develop a joint strategy by the end of 2009 for the provision of IB skills; and ensure the pipeline of talent is captured.

#### • Recommendation 13:

The IB-IGT recommends that industry works with EPSRC, BBSRC, academia and the professional institutions to develop and fund a new taught MSc, MRes or similar type of programme for codevelopment of advanced practical skills in IB.

#### • Recommendation 14:

The IB-IGT recommends that industry work with EPSRC, BBSRC and Higher Education Institutions to identify additional mechanisms for co-funded post-doctoral researchers to allow UK Centres of Excellence to compete effectively with equivalents in the EU.

### Theme 5: Perception and Awareness

#### • Recommendation 15:

The IB-IGT recommends the endorsement, and recommended adoption, of PAS 2050 for lifecycle GHG emissions as the standard methodology for accessing lifecycle greenhouse gas emissions in goods and services.

#### • Recommendation 16:

The IB-IGT recommends the endorsement, and recommended adoption, of Carbon Calculations over the Life Cycle of Industrial Activities (CCaLC) as the preferred toolkit for the calculation of a product's carbon footprint.

#### • Recommendation 17:

The IB-IGT recommends the endorsement, and recommended adoption, of a standard for calculating the bio-based content of a product.

#### • Recommendation 18:

The IB-IGT recommends that, where areas of concern are raised by industry, with supporting evidence, new and existing obligations and incentives be reviewed by the Government with a view to addressing any identified unintended consequences blocking the application of IB to high-value chemical usage; and, where appropriate, this evidence be used to raise relevant issues with the European Commission where the Commission holds the mandate.

#### • Recommendation 19:

The IB-IGT recommends that the Government accepts and includes the role bio-based products, and products made via bioprocesses, can play in delivering sustainable public procurement across the Government Estate, and specifically acts by spring 2010 to:

o Develop an evidence base to identify and quantify the potential of bio-based products in terms of their contribution to reducing the Government Estate's carbon footprint, GHG emissions and overall sustainability (including lifecycle analysis, carbon foot-printing and bio-based content calculations)

o Adopt a whole lifecycle approach to decisions related to Government Estate and procurement policy

o Identify where the opportunities lie for Government to lead by example through procuring, and stimulating innovation in, bio-based products and processes

o Integrate with and seek to influence the work on sustainable procurement in the European Commission, such as the Lead Market Initiative for bio-based products, the call for proposals to support lead markets public procurement networks, the Strategic Energy, Technology (SET) Plan, and the Sustainable Consumption and Production (SCP) and Sustainable Industrial Policy (SIP) Action Plan.

#### • Recommendation 20:

The IB-IGT recommends that IB is considered as a value-creating demand factor when developing a strategy for managing sustainable land use in the context of intensification of demand for all purposes.

#### • Recommendation 21:

The IB-IGT recommends that Government, industry, Research Councils, NGOs, and professional institutions should develop an effective, balanced and informative communication strategy, including stakeholder and public engagement, for IB.

## ANNEX 2: Timeline of IB Milestones and Activity 2009-2014

Nov-07	IB-IGT established
May-09	IB-IGT report published describing £12bn IB opportunity by 2025
Jun-09	Government response released
Sep-09	BIS invest £12m for demonstration scale National IB Facility (NIBF) at CPI
Oct-09	IBLF established with Ian Shott as Chairman
Oct-09	1st annual £2.5m Innovation competition for High Value Chemicals through Industrial Biotechnology (HVC-IB) funded by BIS and Innovate UK
Feb-10	IB team established within KTN through additional Innovate UK funding
Apr-10	BBSRC stipulates 'Industrial Biotechnology & Bioenergy' as one of three new strategic science priorities enshrined within its Strategic Plan 2010-2015
Jul-10	Mark Prisk MP announced as IBLF Ministerial Co-Chair
Oct-10	£2.5m Innovate UK competition HVC-IB (II) for feasibility and CR&D opens
Oct-10	IB event week in Edinburgh including EFIB, IChemE and KTN conferences
Oct-10	Horizon scanning and roadmapping for IB to 2025 published to IBLF by AD Little
Jan-11	IB Stakeholder Council, chaired by Jonathon Porritt, formed
Feb-11	Innovate UK and Innovation Norway sign 5 year Memorandum of Understanding to collaborate on IB
Mar-11	Yvonne Armitage appointed by KTN as IB Sector Expert
May-11	CPI launches demonstration scale National IB Facility (NIBF) following £12m BIS investment
Jun-11	First meeting of BBSRC's Industrial Biotechnology Strategy Advisory Panel (IB-SAP)
Aug-11	UK-Norway IB event: Biocatalysis
Sep-11	Cogent IB Working Group on skills launched
Sep-11	IB event: Opportunities in Personal Care Products
Oct-11	£2.5m Innovate UK competition HVC-IB (III) for feasibility and CR&D opens
Oct-11	Biorefinery Centre opens at Institute of Food Research (Norwich)
Feb-12	EPSRC's Sustainable Chemical Feedstocks Competition opens
Mar-12	IBLF Leading IB event: Focus on Biorefining
Mar-12	Innovate UK & BBSRC develop international activities in IBBE leading to participation and co-funding of projects in ERA_IB
May-12	IBLF Leading IB event: Focus on Biocatalysis
Jul-12	Biorenewables Development Centre opens in York following £2.5m investment from BIS
Jul-12	KTN IB team complete 100 company visits on potential of IB
Aug-12	Mark Prisk MP visits Croda's industrial biotechnology facility in Widnes
Sep-12	IBLF Leading IB event: Focus on Biobased Products
Sep-12	IBLF skills sub team initiated
Oct-12	BEACON Programme launched by Abersytwyth University following £10m ERDF investment through Welsh Government
Oct-12	£2.5m Innovate UK competition HVC-IB (IV) for feasibility and CR&D opens
Oct-12	Michael Fallon assumes responsibility as IBLF Ministerial Co-Chair
Dec-12	BBSRC's first major investment in a sLoLa under its IB strategy - £3.6m over 5 years to the University of Manchester
Jan-13	IBLF Leading IB event: A UK Showcase
Jan-13	IBLF finance sub-committee present results of initial work

Dec-12	Revenues from IB products estimated in UK at £4-5bn
Jan-13	"Sustainable Returns: IB Done Well" report published by Jonathon Porritt
Jan-13	David Willetts announces new IB investments (£45m) through a coordinated strategy between BBSRC, Innovate UK and EPSRC
Apr-13	Innovate UK announce investment of £38m in National Biologics Manufacturing Centre at CPI
Jun-13	Steve Bagshaw appointed as IBLF Chair
Jun-13	UK-Norway IB Event: Valorising Woody Biomass
Aug-13	IB Manufacturing Exhibition at BIS (1 Victoria Street, London)
Sep-13	FCO/BBSRC/KTN led Innovation Mission to Japan with industry and academic participants
Oct-13	£2.5m Innovate UK competition HVC-IB (V) for feasibility and CR&D call opens
Nov-13	Launch of Scotland's National Plan for Industrial Biotechnology
Nov-13	KTN hosts UK workshop for EU BIO-TIC on Barriers to IB
Dec-13	£18m Research Council (BBSRC & EPSRC) investment into 13 BBSRC NIBB
Nov-13	PAS600 Guidance on Biobased Products launched
Jan-14	IBiolC launched with £10m investment
Jan-14	BBSRC/EPSRC/Innovate UK £45m IB Catalyst Round 1 opens
Apr-14	First meeting of IBLF, Synthetic Biology Leadership Council and Agri-Tech Leadership Council industrial chairs
May-14	BBSRC/EPSRC/Innovate UK £45m IB Catalyst Round 2 opens
May-14	Communicating IB Ambassadors workshop
Jun-14	IBLF event: Consumer Products through IB across the Value Chain
Jul-14	Science Industry Partnership Skills Training Programme for the process industries launched with £52m investment
Aug-14	Matthew Hancock assumes IBLF Ministerial Co-Chair responsibility
Sep-14	IBLF event: Exploring the Challenges in Downstream Processing for IB
Oct-14	BBSRC, Innovate UK and EPSRC announce first round of IB Catalyst grants, with a total commitment of £21m
Oct-14	BBSRC invest in 3 new sLoLas totalling £9.9m
Dec-14	BBSRC/EPSRC/Innovate UK £40m IB Catalyst Round 3 opens

## ANNEX 3: List of Acronyms

**ATLC:** Agri-Technology Leadership Council

**ATP:** Advanced Training Partnership

**BBSRC:** Biotechnology and Biological Sciences Research Council

**BIS:** Department for Business, Innovation and Skills

**BRIC:** Bioprocessing Research Industry Club

**BSI:** British Standards Institution

**CPI:** Centre for Process Innovation

**EPSRC:** Engineering and Physical Sciences Research Council

**EU FP7:** European Framework Programme 7

**IB:** Industrial Biotechnology

**IB-IGT:** Industrial Biotechnology Innovation and Growth Team

**IBiolC:** Industrial Biotechnology Innovation Centre

**IBLF:** Industrial Biotechnology Leadership Forum

**IBTI:** Integrated Biorefining Technology Industry Club

**IChemE:** Institution of Chemical Engineers

**KTN:** Knowledge Transfer Network

**BBSRC NIBB:** BBSRC Networks in Industrial Biotechnology and Bioenergy

**PAS:** Publicly Available Specification

**SBLC:** Synthetic Biology Leadership Council

**SFC:** Scottish Funding Council

**sLoLa:** strategic Longer, Larger grants

**SIP:** Science Industry Partnership

**UKTI:** UK Trade & Investment



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