

2017

UK SYNTHETIC BIOLOGY
Start-up Survey

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Foreword

Our vision for synthetic biology is for the UK to become the world leader in the development, delivery and commercialisation of the science and technology that exploits synthetic biology.

Where business can start, grow and confidently develop new products and services – delivering them rapidly, efficiently and effectively to the market place. We envisage establishing a new and sustainable bioindustry that has attractive investment opportunities for both public and private capital. This will drive the growth of the UK bioeconomy – producing novel products, processes and highly skilled jobs across every major industrial sector.

This report shows that the UK's synthetic biology innovation ecosystem is developing rapidly – creating economic growth and new high value jobs for the economy. Building on academic research funded by UKRI, and the work at

our world-leading universities and research institutions, the ecosystem comprises start-ups and SMEs (funded by venture capital) and established industrial biotechnology companies (funded by the private markets). Effective nurturing of the ecosystem requires continued support through funding of early-stage research and translation, open engagement with regulatory and public stakeholders, and appropriate rewards for breakthrough innovations. If this can be achieved, then all will benefit. If not, then a major opportunity will be lost.

The UK strategy for synthetic biology has been defined by a number of influential reports^{1,2,3} – placing synthetic biology as a key driver of the UK bioeconomy. As part of this strategy, the UK national industrial translation centre for synthetic biology, SynbiCITE, established in 2013, is central to the vision and implementation of

the commercial development of synthetic biology. The effective translation of academic research requires substantial financial investment, as well as the skills and training necessary to commercialise these opportunities. SynbiCITE's role is to nucleate the activities and resources required and apply them across the UK.

As this survey illustrates, today the UK has a growing and vibrant synthetic biology start-up and SME ecosystem. In the recent acceleration of growth of companies exploiting synthetic biology in the UK, SynbiCITE is just one element in a complex ecosystem, which supports discovery, innovation and the commercialisation, of which we are proud to be a part.

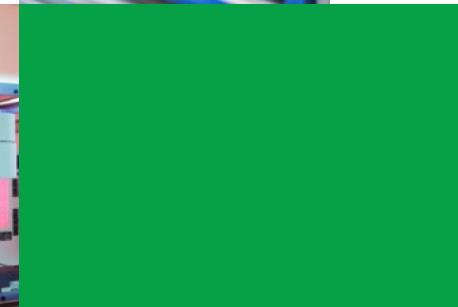
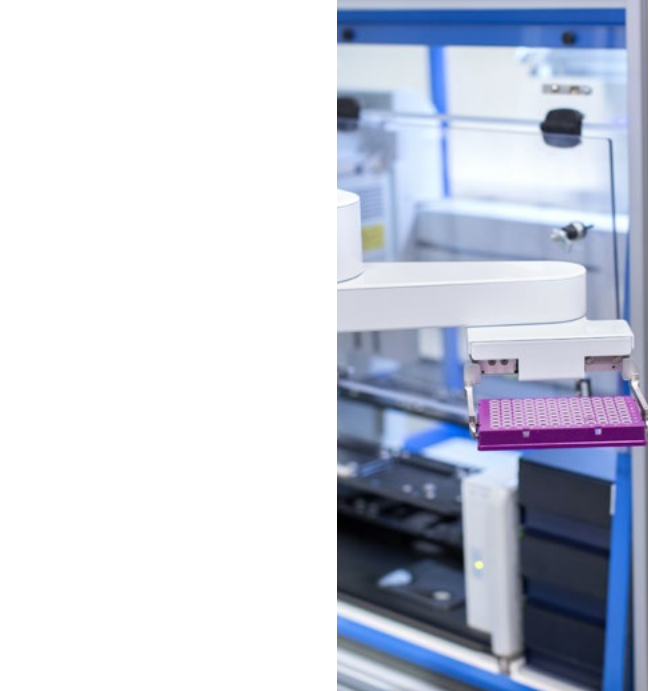


Prof R. Kitney
Co-director
SynbiCITE



Prof P. Freemont
Co-director
SynbiCITE

1 <http://www.raeng.org.uk/publications/reports/synthetic-biology-report>
2 <http://www.rcuk.ac.uk/documents/publications/syntheticbiologyroadmap-pdf>
3 <http://goo.gl/TiXMhu>



Executive Summary

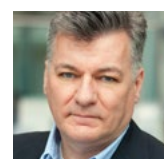
The publication of 'A Synthetic Biology Roadmap for the UK' in 2012 resulted in significant Government investment in synthetic biology. Over £300 million was invested through the Research Councils UK and Innovate UK to establish six new Synthetic Biology Research Centres (SBRC: Universities of Bristol, Edinburgh, Manchester, Nottingham, Cambridge/John Innes Centre and Warwick), three Doctoral Training Centres (DTC: Universities of Oxford, Bristol and Warwick), and an Innovation and Knowledge Centre (IKC: SynbiCITE at Imperial College London) to drive the commercial translation of synthetic biology research. The UK Government's commitment to the commercialisation of synthetic biology research outputs was further reinforced with an additional £10 million investment in the Rainbow Seed Fund for synthetic biology spin-outs and start-ups.

SynbiCITE, as the UK National Centre for the Translation and Commercialisation of Synthetic Biology, has overseen the growth in entrepreneurship programmes directed at the UK synthetic biology community. Entrepreneurs looking to exploit synthetic biology now have access to more translational resources than ever before. The creation of start-up competitions, mentorship programmes, seed funds and entrepreneurial training programmes is helping to develop new ideas and turn technologies into viable businesses. Following the UK Government's investment in synthetic biology, the expansion of these resources is now starting to paying dividends with an increase in the formation of start-up businesses.

For this first annual edition of the UK's Synthetic Biology Start-up Survey, SynbiCITE partnered with Rainbow Seed Fund and Innovate UK and other data providers to establish a comprehensive picture of synthetic biology entrepreneurial activity taking place across the UK. As well as capturing the aggregate numbers of start-ups and spin-outs, we have also explored regional variation, funding activity and the industrial sectors represented in these numbers.

This survey of how many companies are being formed provides no qualitative interpretation on the individual companies; it simply attempts to provide a high-level overview of the sector. We also recognise that an increase in the numbers of start-ups is not necessarily good, just as a decrease is not necessarily bad. Having said that, because of the natural attrition that occurs when starting and running companies, the population of this sector needs to be continually resupplied, and so any decrease in the number of start-ups would be an issue. In this rapidly developing sector, we also need to understand the trends which are taking place if we are to help this innovative ecosystem to grow and flourish.

Our plan going forward is to produce an annual survey, using the same databases and methodology for analysis. Hopefully, you will find this survey interesting and useful.

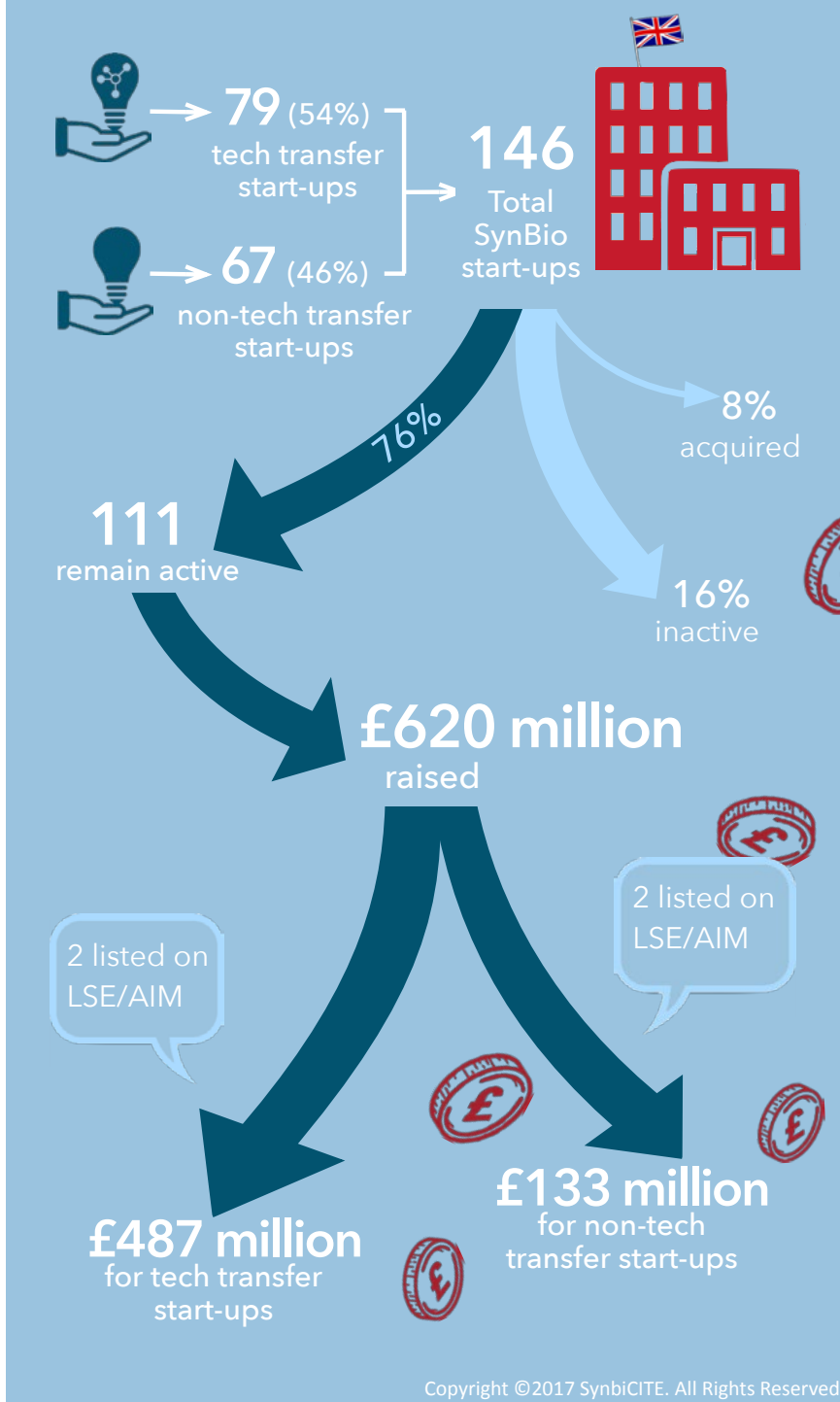


Stephen Chambers PhD
CEO
SynbiCITE

£300m

Between 2009-2016 UK Government invested £300m in synthetic biology

UK SYNTHETIC BIOLOGY START-UPS 2000-2016

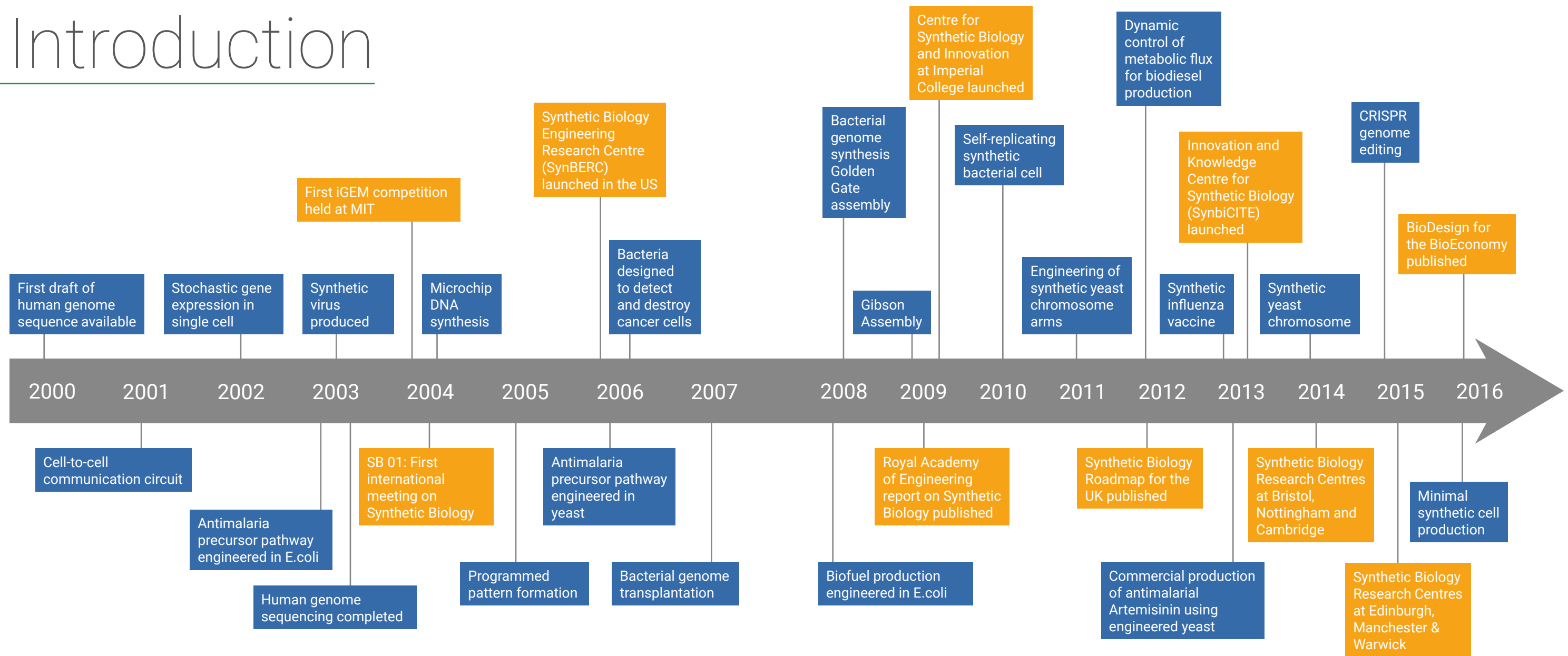


Key Findings

- The UK produced more than 146 synthetic biology start-ups between 2000 and 2016. On average, the number of synthetic biology companies has been doubling every five years.
- More than half (54%) of new start-ups are tech transfer start-ups, with fewer (46%) non-tech transfer start-ups produced over the same period. The creation of non-tech transfer start-ups is outpacing traditional tech transfer start-ups (2:1), which have remained static over the same period.
- Approximately 76% of all the start-ups founded are still active, of the remaining: 8% were acquired and 16% of the companies are inactive.
- Synthetic biology start-up activity is concentrated in the South-East, East of England and London (67%). With Oxford, Cambridge and London Universities producing a cluster of activity nucleating in and around London.
- Synthetic biology start-up companies have raised over £620m of public (£56m) and private (£564m) investment in the UK since 2010. Private investment peaked in 2015 with over £232m raised.



Introduction



Over forty years ago, advances in molecular biology created modern biotechnology, responsible for much of today's \$2.2 trillion global bioeconomy. Recent developments in synthetic biology are creating the next wave of biotechnology innovation and growth of the bioeconomy. This new wave of industrial biotechnology applies innovations in synthetic biology to enable the engineering of biology, creating novel products and services. As with the initial

development of biotechnology, this second wave is being driven by innovative start-ups and small companies exploiting synthetic biology to create a new industry. Importantly, the continued expansion of the bioeconomy, now through foundational technologies like synthetic biology, provides a means of re-industrialisation at a time when traditional manufacturing is in decline.

The watershed event that separated these two waves of biotechnology, and also marked the coming-of-age of synthetic biology, was the sequencing of the human genome in 2001. The current post-genomic era is characterised by technology developments in DNA sequencing and synthesis resulting in a dramatic reduction in the cost of reading and writing DNA. The ability to read and write DNA has transformed both our

understanding of biology and our ability to engineer biology. Like its predecessor (molecular biology), engineering biology is an enabling technology, which is delivering transformation across many industrial sectors including: Pharma/Biotech, Chemicals, AgriTech, Tools & Services.



The Numbers

There has been a steady increase in the number of synthetic biology start-ups over the period examined (2000-2016), with an average of 7 companies started each year. The smallest number of start-ups was in 2008, during the financial crisis, with only 2 companies formed. Two years later, in 2010, the economic environment had recovered with a return to above average numbers of company starts. Since 2016 there has been a slight dip in company formation. For the past two years, numbers have been down from a five-year high of 11 start-ups in 2014.

It is important not to place too much significance on the total number of start-ups, more is not necessarily better, but these new businesses will go on and form the next generation of companies. The level of start-up activity can be used to gauge the health of the sector.

Much of the growth in synthetic biology start-up activity can be attributed to a rapid rise in non-tech transfer start-ups – companies that do not license university technology.

The growing trend for non-tech transfer start-ups reflects a change underway at some university tech transfer offices. Leading US & UK universities are adapting their business aims and models. The focus is moving to creation of start-up companies and early engagement with the private sector. The changes are the result of increased pressure on universities to efficiently manage both their human capital and intellectual assets. To produce greater economic benefit from their teaching and research to improve the return on investment to the taxpayer.



Tech transfer offices are undergoing a shift in culture from capturing value for the institution to creating value for society – and being an active contributor to the innovation ecosystem

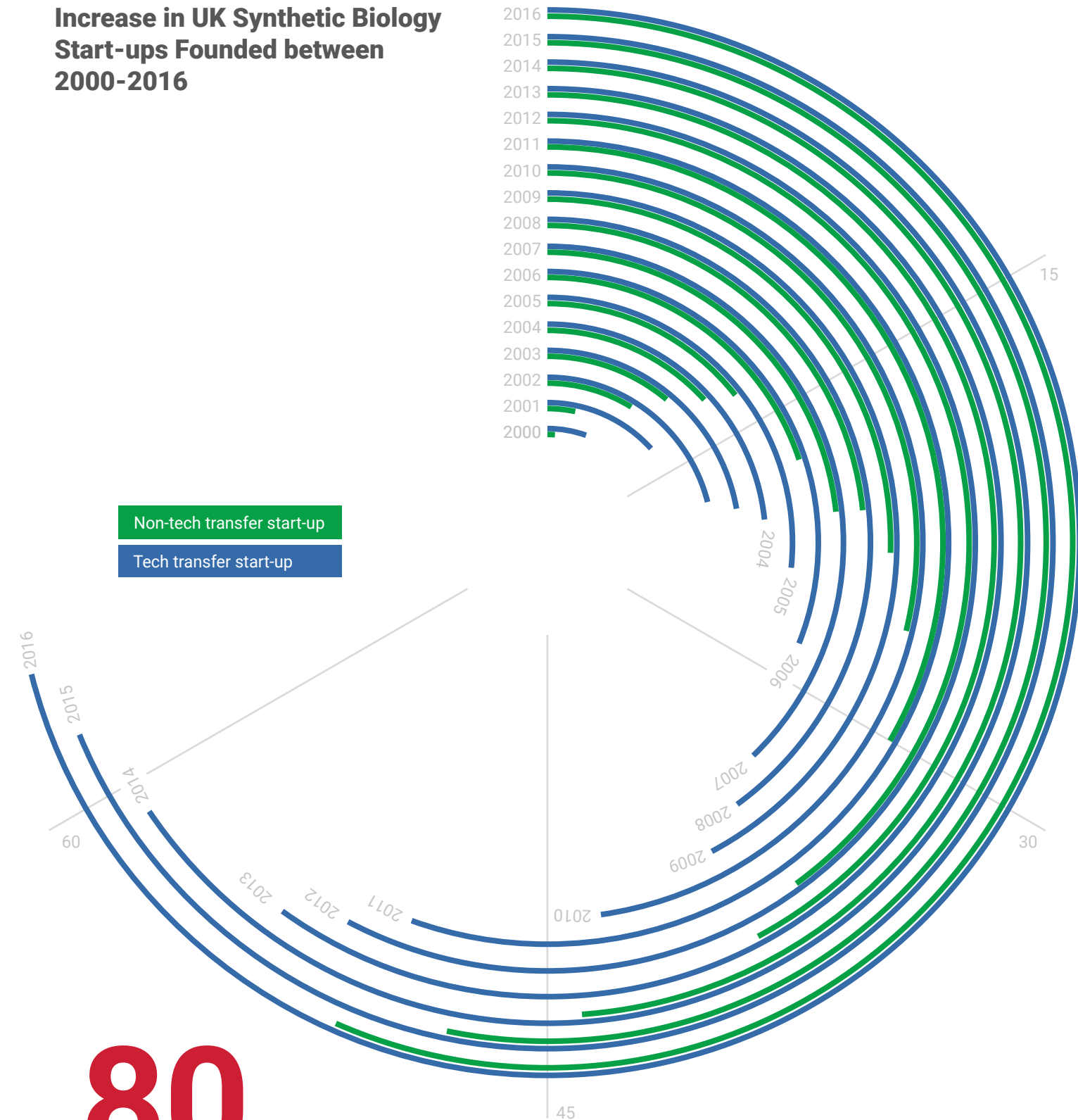
Prof Jerry Engel, Haas School of Business, UC Berkeley & National Faculty Director, I-Corps

TECH TRANSFER VS NON-TECH TRANSFER

Tech transfer start-ups are created when a technology developed in a university or institute is licensed into a new company and spun-out. The university continues to have a vested interest in seeing the new company succeed, often providing seed funding and incubator facilities.

Non-tech transfer start-ups are often founded by university personnel (faculty and staff) or students, but do not license technology from the university. Increasingly these companies have often been incentivised or directly supported by university entrepreneurship programmes linked to financing (Lean LaunchPad and ICURe).

Increase in UK Synthetic Biology Start-ups Founded between 2000-2016



80%

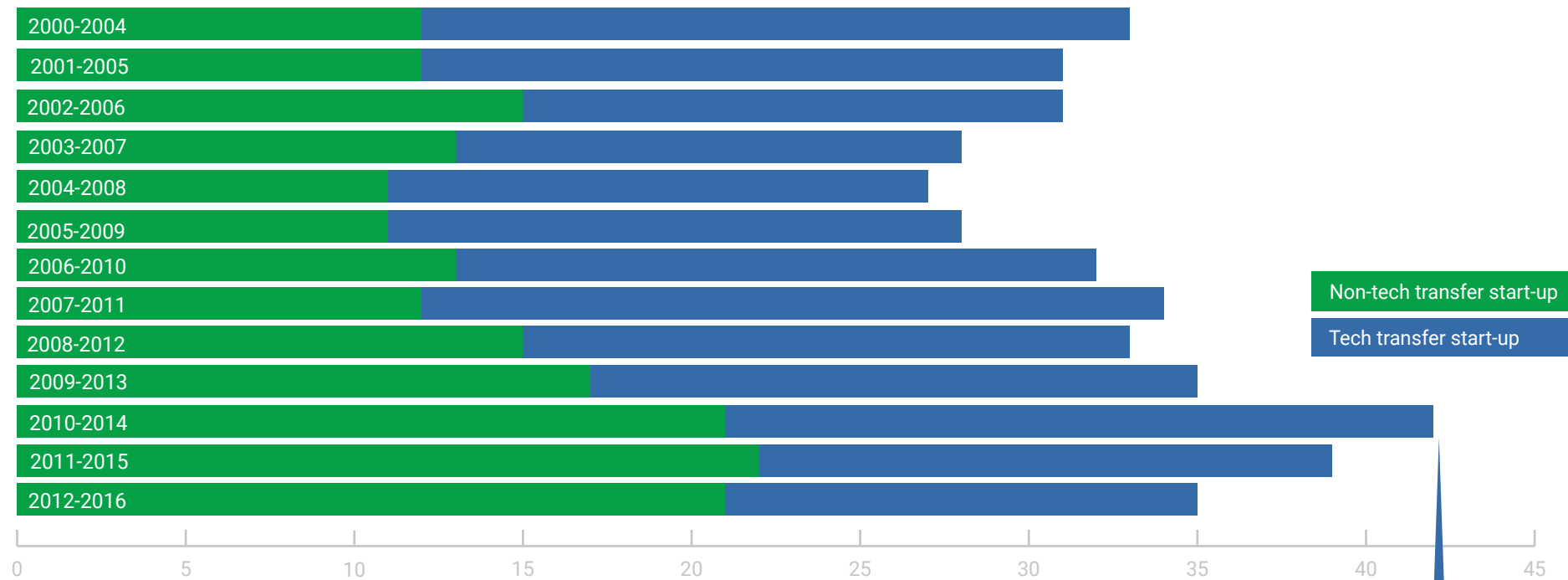
Approximately 80% of all start-ups from Illinois universities are part of a newer breed of companies (non-tech transfer university start-ups) usually founded by students, the product of a greater emphasis on start-up competitions and entrepreneurial training at these universities.

Illinois Innovation Index Winter 2016



The Numbers

Number of Synthetic Biology Start-ups



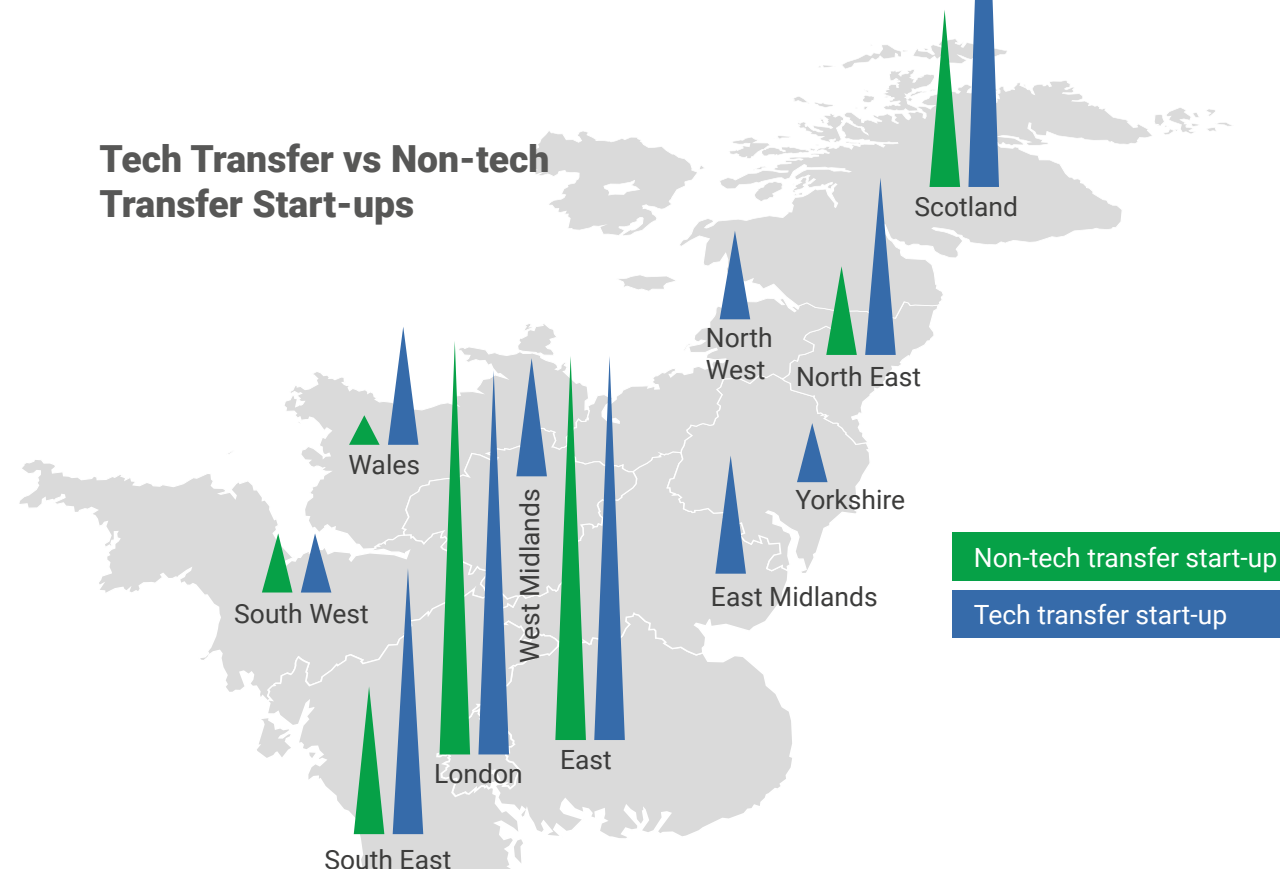
An average of 34 synthetic biology start-ups were formed in each rolling five-year period from 2000-2016, rising significantly during 2010-2014 to 43.

A rolling five-year period was employed in our analysis to avoid random fluctuations in annual data arising from the small sample set.

A slight drop is observed in 2012-2016, compared to 2011-2015 and the high of 2010-2014. There has been a doubling of non-tech transfer start-ups between 2000-2006 and 2012-2016. Non-tech transfer start-ups are part of a growing enterprise culture which is encouraging entrepreneurial activity, hitherto relatively untapped. The increase in non-tech transfer start-up activity is in contrast to tech transfer start-up activity, which has remained fairly constant over the same period.

The type of start-up also appears to have a regional dimension with more non-tech transfer start-ups located in areas of the UK that already have a higher concentration of start-up activity. London leads the way with more overall start-ups and non-tech transfer start-ups than the traditional tech transfer university start-up (spin-out). This is closely followed by the East of England, which has equal numbers of non-tech transfer and tech transfer start-ups. In all the other regions of the UK traditional tech transfer start-ups dominate; with little or no evidence of non-tech transfer start-ups.

Tech Transfer vs Non-tech Transfer Start-ups



UK universities produce equivalent numbers of patents and licensing agreements per-unit research funds as their US counterparts, but generate significantly lower income. Technology transfer offices in the UK usually demand a larger equity share and universities tend to view IP as a way of making money, which lowers the incentive for entrepreneurship. In contrast, leading US universities, like MIT, take a more hands-off approach and view entrepreneurial activity as reputation enhancing rather than income generating.

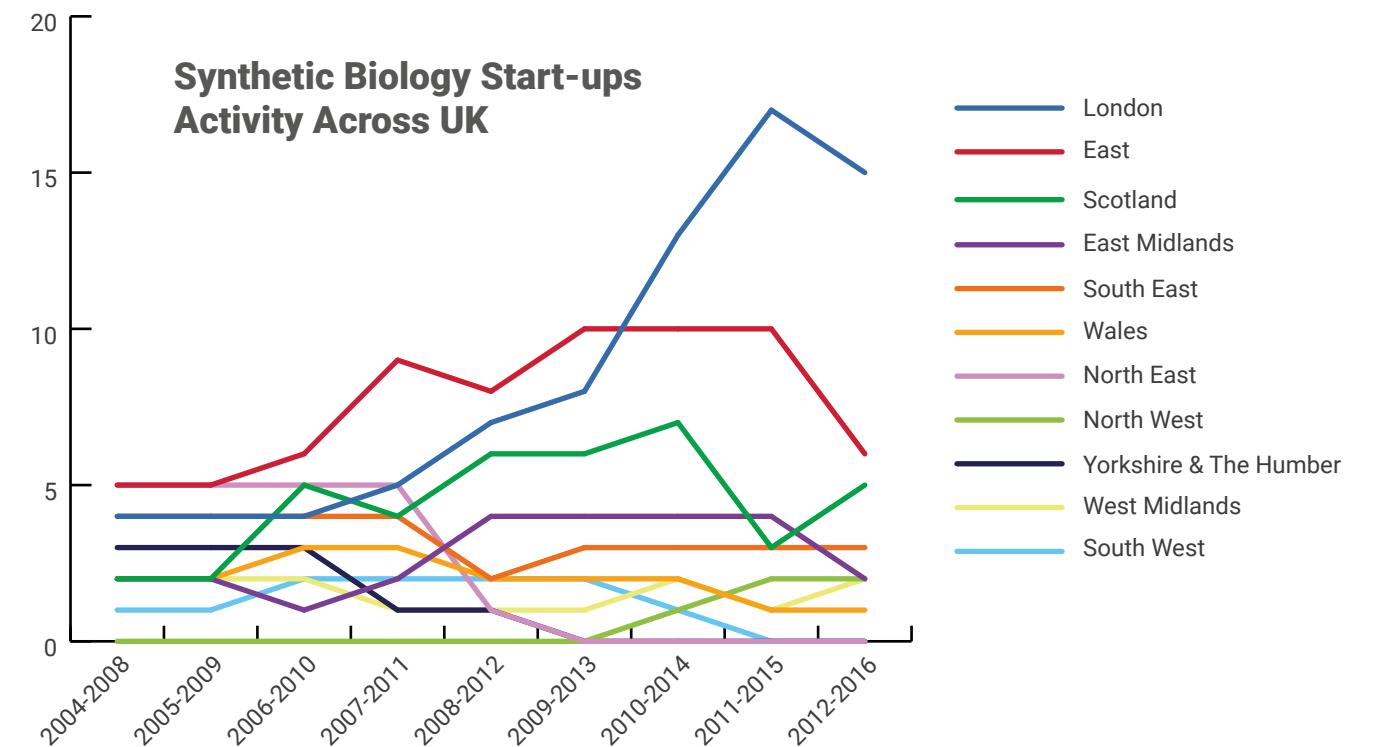
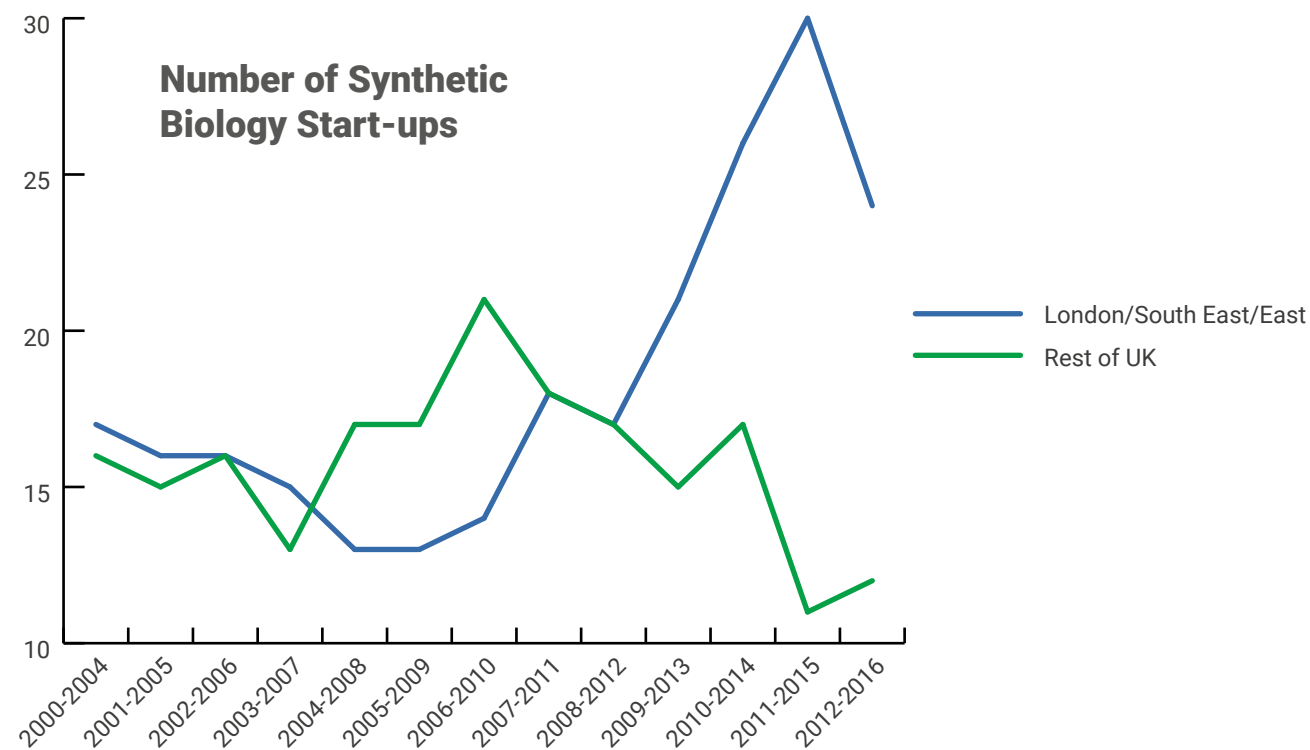
Paul Carlile, Dean of Innovation at Boston University



The Numbers

Concentration of synthetic biology start-up activity in London and the South East is not surprising given its location within the 'golden triangle' of London, Oxford and Cambridge. These global centres of excellence in research, innovation and skills are all essential elements for start-up growth. This nucleation of entrepreneurial activity, or clusters of innovation, are increasingly important in the development of start-ups.

This nucleation of entrepreneurial activity, or clusters of innovation are increasingly important in the development of start-ups



The picture across the UK is one of widely varying trends: London has clearly emerged as the leading region for synthetic biology start-ups. A surge of company formation took place in London during 2010-2014, overtaking the East of England, which saw a levelling off and a subsequent fall in the level of activity over the same period. It is too early to say if the recent fall in start-up activity is just a blip. The upturn in Scotland may well be linked to differences in public sector support for start-ups.

A surge of company formation took place in London during 2010-2014



The Numbers

Many of today's synthetic biology start-ups are Tools & Services or platform companies. Horizon Discovery and Desktop Genetics for example, are both focused on developing a variety of services to exploit the single gene-editing technology, Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR).

The recent decline in Tools & Services and rise of Pharma/Biotech and other start-ups can be interpreted as the sector maturing with more product companies being created. This trend would have some parallels with the development of the first wave of biotechnology start-ups, many of which were platform companies, which later transitioned into product-led businesses. While Tools & Services companies dominate, the East of England leads all the UK regions with the highest number of Pharma/Biotech companies.

Historically, Pharma/Biotech start-ups are product companies, focused on developing a single product, directed to treat a single disease or disease indication. Genentech's first product was human growth hormone, Amgen got its start by marketing Erythropoietin, while Gilead's origins centred on antivirals. Tools & Services start-ups are platform companies offering a capability that can be applied across a broad range of applications. These can consist of reagents, laboratory diagnostics, testing devices or broader therapeutic protocols. Illumina initially used its bead array technology platform to deliver single nucleotide polymorphism genotyping as a service. The dichotomy between product and platform is not absolute. Some start-ups appear to straddle the boundaries between product and platform companies, initially selling Tools & Services and then transition to selling a product.

COMPANY SPOTLIGHT

Desktop Genetics

Desktop Genetics is a UK-based bioinformatics company building an AI for CRISPR genome editing. Its software and technologies are currently used by the world's best clinical genome editing companies to diagnose and treat the root cause of genetic disease.



Desktop Genetics collaborates with the CRISPR community to design new genomics libraries and advance what's possible with CRISPR genome engineering.

- Founded 2012
- Based in London and Cambridge, MA
- Created AutoClone: a software tool that accelerates genetics research
- Investment from Illumina to support integration with NGS pipeline and improve CRISPR Genome editing workflows

COMPANY SPOTLIGHT

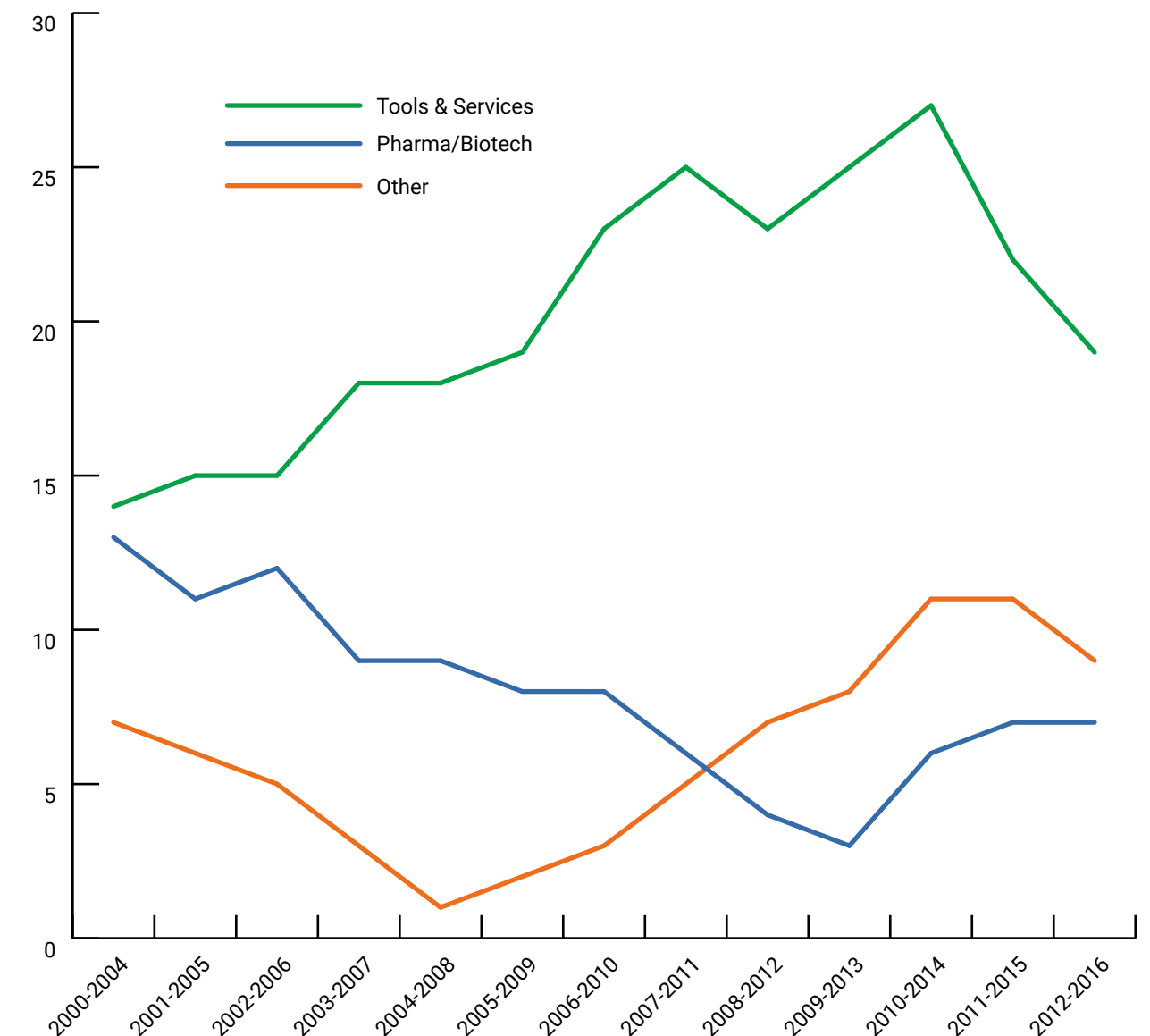
Horizon Discovery

Horizon Discovery is a gene editing company that designs and engineers genetically modified cells providing biological insights, improving research and development outcomes for drug companies.



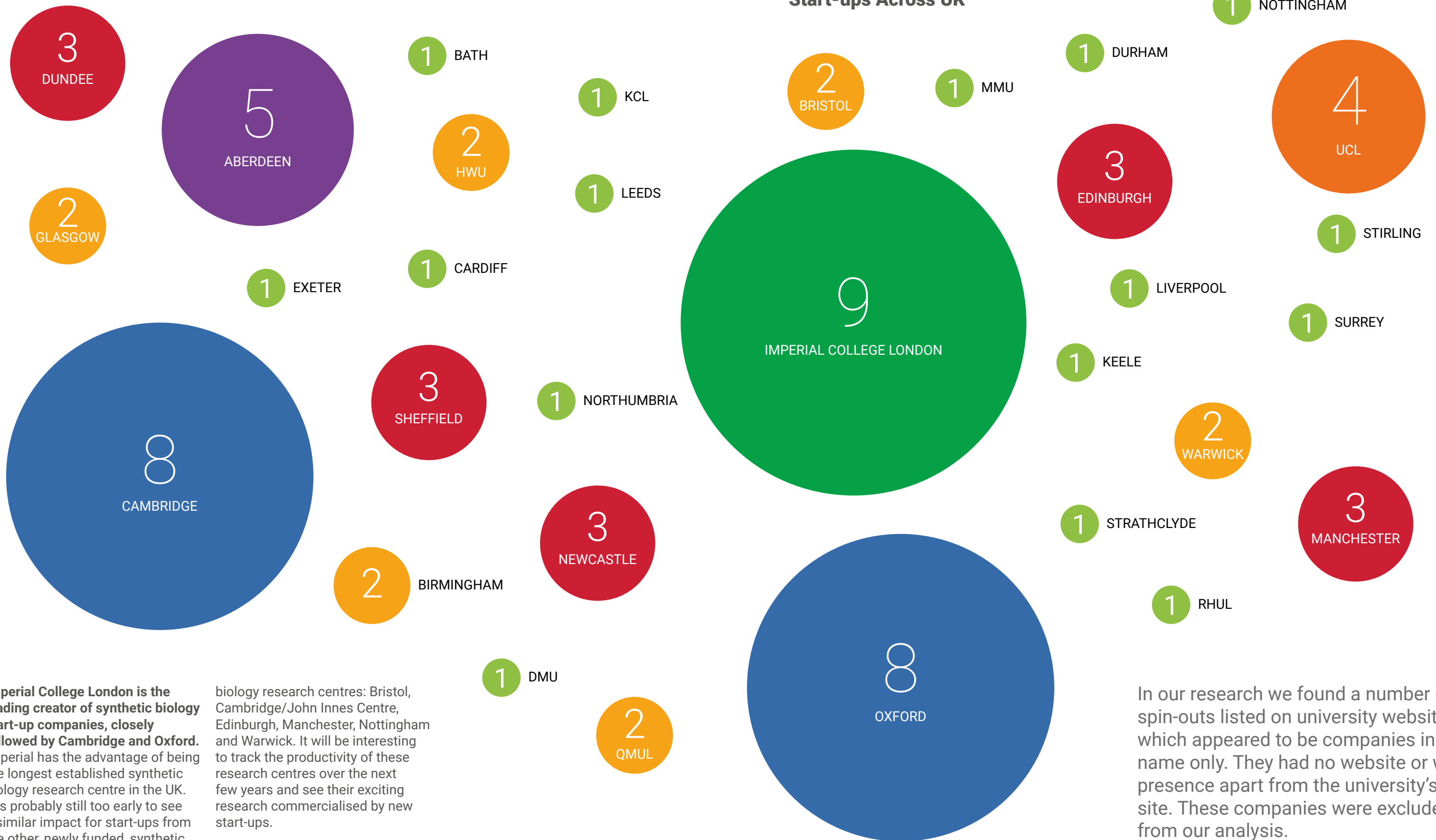
- Founded in 2007
- Cambridge University non-tech transfer start-up
- Raised £39m private equity
- 2014 went public IPO on LSE (AIM:HZD)
- Acquired SAGE Labs 2014 for \$25m cash

Pharma/Biotech and Tools & Services Start-ups



Universities

University Synthetic Biology Start-ups Across UK



Imperial College London is the leading creator of synthetic biology start-up companies, closely followed by Cambridge and Oxford. Imperial has the advantage of being the longest established synthetic biology research centre in the UK. It is probably still too early to see a similar impact for start-ups from the other, newly funded, synthetic

biology research centres: Bristol, Cambridge/John Innes Centre, Edinburgh, Manchester, Nottingham and Warwick. It will be interesting to track the productivity of these research centres over the next few years and see their exciting research commercialised by new start-ups.

In our research we found a number of spin-outs listed on university websites which appeared to be companies in name only. They had no website or web presence apart from the university's site. These companies were excluded from our analysis.



Research Centres



The UK Centre for Mammalian Synthetic Biology Research at the University of Edinburgh is building expertise in cell engineering tool generation, whole-cell modelling, computer-assisted design and assembly of DNA and high-throughput phenotyping to enable synthetic biology in mammalian systems. Applications include tools and technologies for commercial exploitation by the pharmaceutical and drug testing industries, diagnostics, novel therapeutics, protein-based drugs and regenerative medicine.



The Synthetic Biology Research Centre for Fine and Speciality Chemicals at the University of Manchester will use predictive synthetic biology to develop faster, more predictable, novel routes to fine and speciality chemicals production (including new products/intermediates for drug development, agrochemicals, flavor/fragrance components and new materials), and through industrial collaborations, help propel chemicals/natural products production towards 'greener' more sustainable manufacturing processes.



BrisSynBio focuses on applying biomolecular design and assembly in synthetic biology. This includes rational design and engineering of nucleic acids, lipids, peptides and proteins as structural, enzymatic and regulatory components in new biological and bioinspired systems. Applications include: producing agrochemicals, pharmaceuticals and fine chemicals; designing new vaccine platforms; developing products; and establishing new methods to increase wheat yields.



The UK's national industrial centre for synthetic biology is designed to be an effective industrial translation engine, bridging the gap between university-based research and industrial processes to create products and jobs, through industry. It provides a national centre of expertise in technology development and commercialisation – and a nucleating point – for the benefit of the UK economy.



The Synthetic Biology Research Centre at the University of Nottingham focuses on micro-organisms already able to synthesise fixed-carbon products from single-carbon gases but applies synthetic biology approaches to engineer-in enhanced chemical production for industrial use. Applications include the sustainable production of chemicals and biofuels. This approach reduces reliance on petrochemicals, reduces climate change and exploits waste.



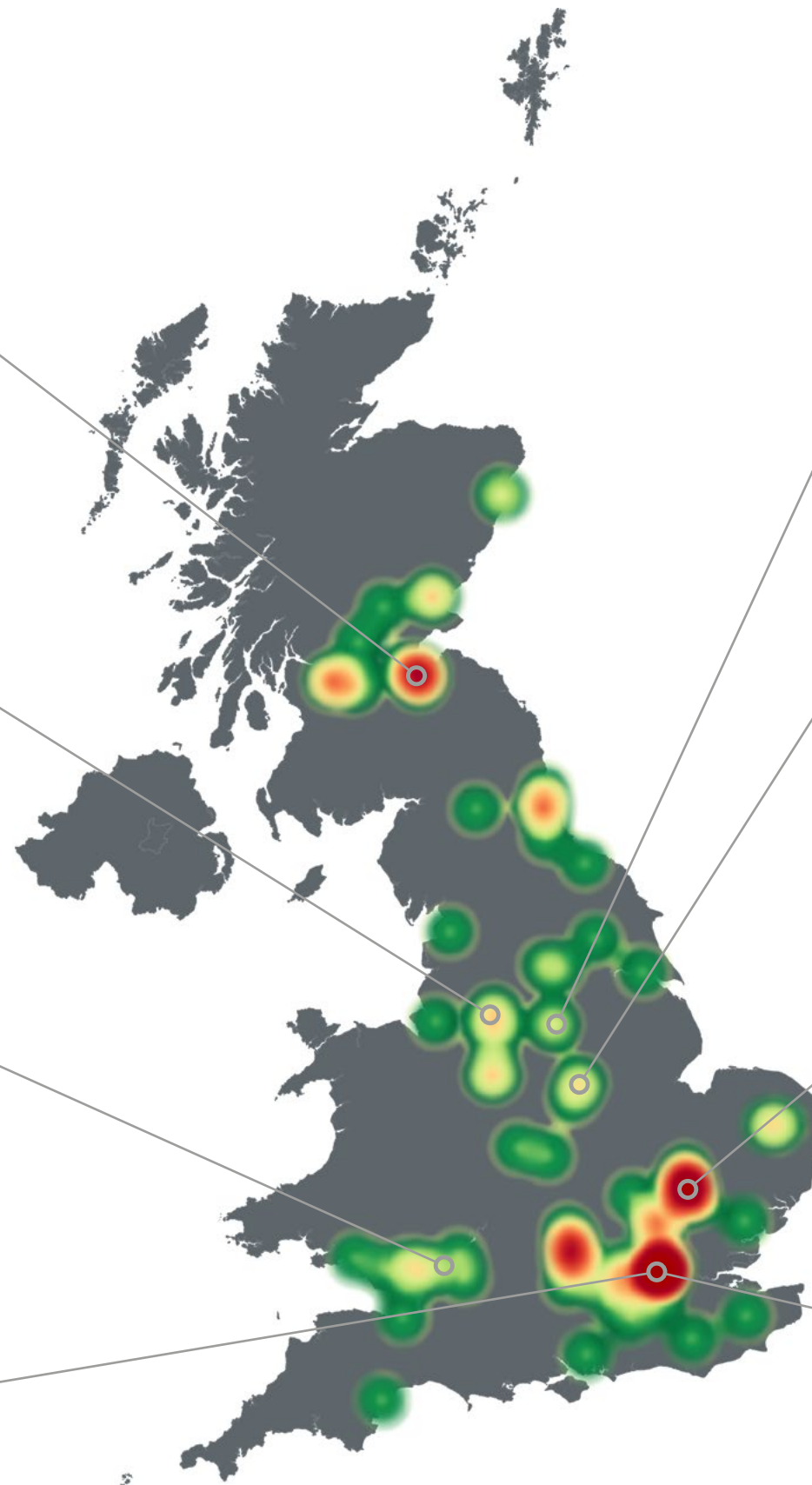
The Warwick Integrative Synthetic Biology Centre addresses specific, industrially relevant design challenges across the scales of biological organisation: genetic circuits, pathways, cells, and multi-cellular systems, also providing us with a better understanding of some of the key mechanistic and evolutionary principles underpinning living systems. Application areas include pharmaceuticals, high-value and commodity chemicals, treatments for disease, environmental bioremediation, bioenergy, and food security.



OpenPlant, a collaboration between the University of Cambridge, the John Innes Centre and The Sainsbury Laboratory in Norwich, is accelerating the development of open technologies for plant synthetic biology and applying these to generate novel plant traits. Applications include metabolic engineering for production of high value products, and foundational work to improve bioenergy sources and enhance photosynthesis and nitrogen fixation.



The Centre for Synthetic Biology and Innovation at Imperial College London applies a twin track research strategy to engineering biology to develop platform technologies and applications. Platform technologies include: information systems, standards (SBOL and DICOM-SB), protocols for characterisation (BioParts, devices and chassis) and DNA assembly. Application areas include: biosensors, biocomputing, production therapeutics, cell-based therapies, advanced biofuels and biomaterials.



Heat gradient on map denotes increasing numbers of synthetic biology start-ups



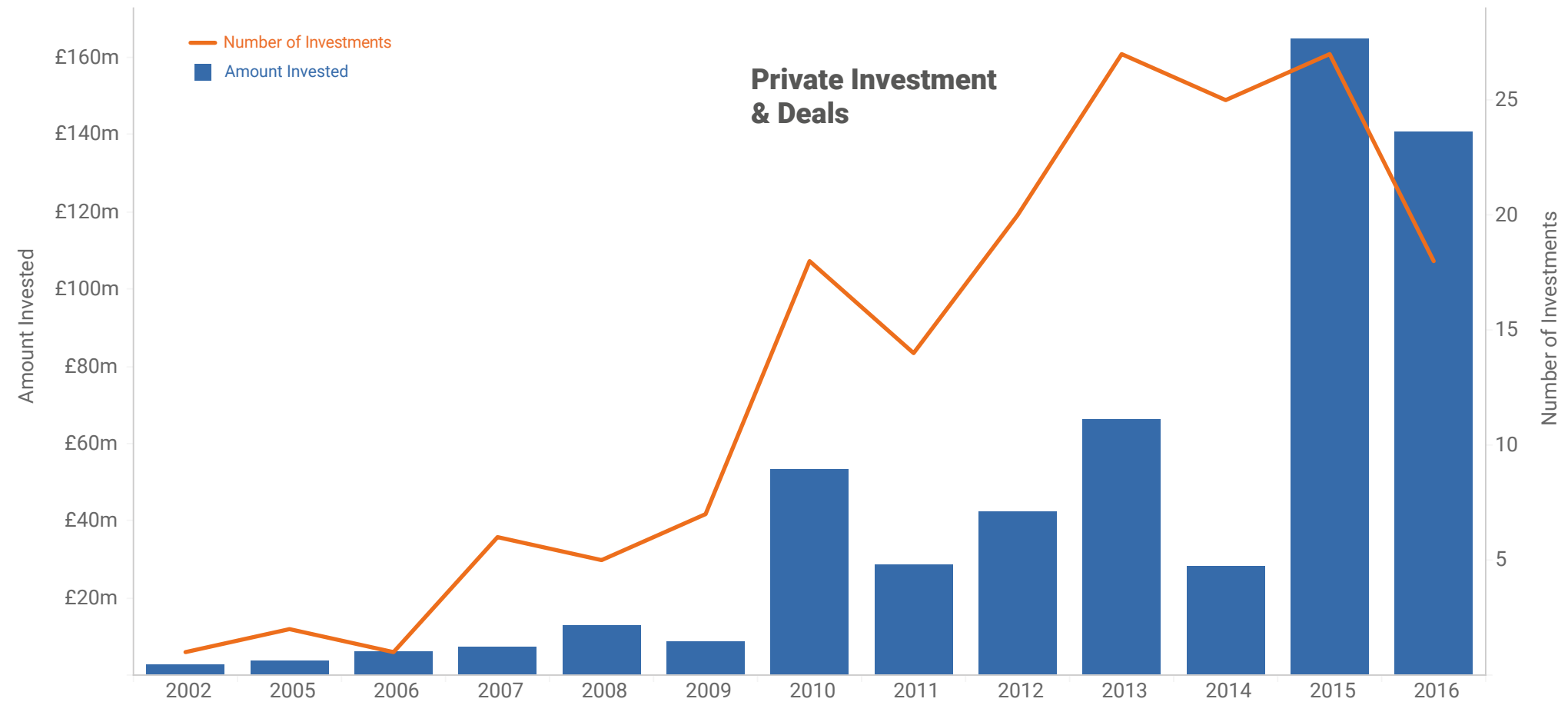
Finance

Commensurate with the growing number of new company formations, UK start-ups are also increasing the amount raised through private investment, with £564m being raised between 2002-2016. Synthetic biology companies raised over £141m during 2016, down from 2015 when £164m was raised. The surge in fundraising in the past 5 years has not been due to an increase in deal numbers but, rather, an increase in the size of deals. The peak of fundraising in 2015 was led by a number of companies: Green Biologics (£60m), Autolus (£30m), 4D Pharm (£30m) and Freeline Therapeutics (£25m).

Although the money raised in 2016 was down compared to 2015, the general outlook for start-ups aiming to raise money has never looked better. However, again, significant regional differences are emerging.

This growth in investment has been helped by a number of successful IPOs and acquisitions in this sector, boosting investor confidence with possible exits.

Four synthetic biology companies (4D Pharm Research: DDDD; BIOME Technology: BIOM; Horizon Discovery: HZD; ValiRx: VAL) are now listed on the Alternative Investment Market (AIM) of the London Stock Exchange (LSE). This along with a number of high profile acquisitions: Intrexon acquired Oxitec for \$160m; has fuelled the positive investor sentiment for synthetic biology start-ups in the UK.



Number of Investments: 171
Total Investment: £564m

Investments that were not publicly announced may be missing for years 2002 to 2008.

Announced: 104 – £501m
Unannounced: 67 – £62.9m

£564m
RAISED BETWEEN 2002-2016

Rainbow Seed Fund

A £10 million investment fund established by the UK Government for synthetic biology spin-outs and start-ups. The fund is open for co-investment from UK and overseas investors.

COMPANY SPOTLIGHT

Oxitec

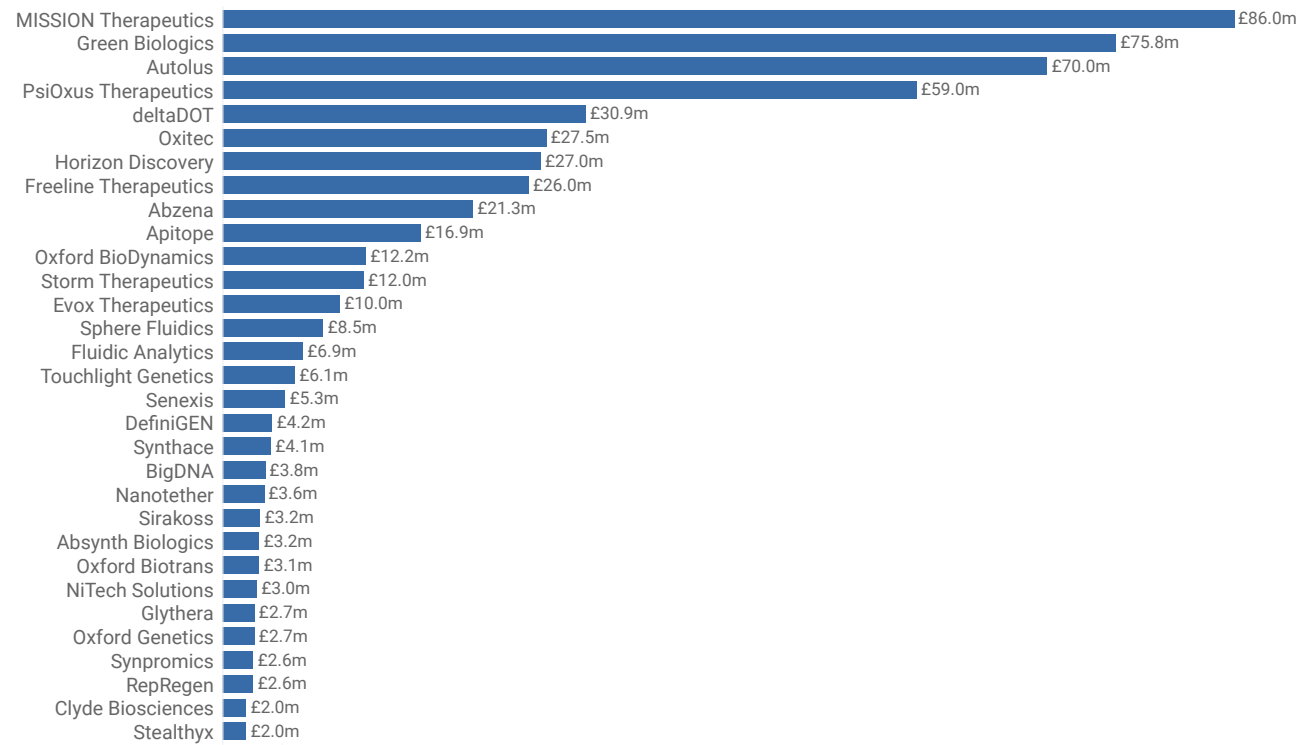
Oxitec has developed genetically engineered mosquitoes to combat insect-borne viral pandemics such as Zika virus and Dengue fever

- Spun out of Oxford University in 2002
- Total raised £25m
- Including £11m under the Enterprise Investment Scheme
- Acquired by Intrexon (NYSE: XON) 2015 for \$160m

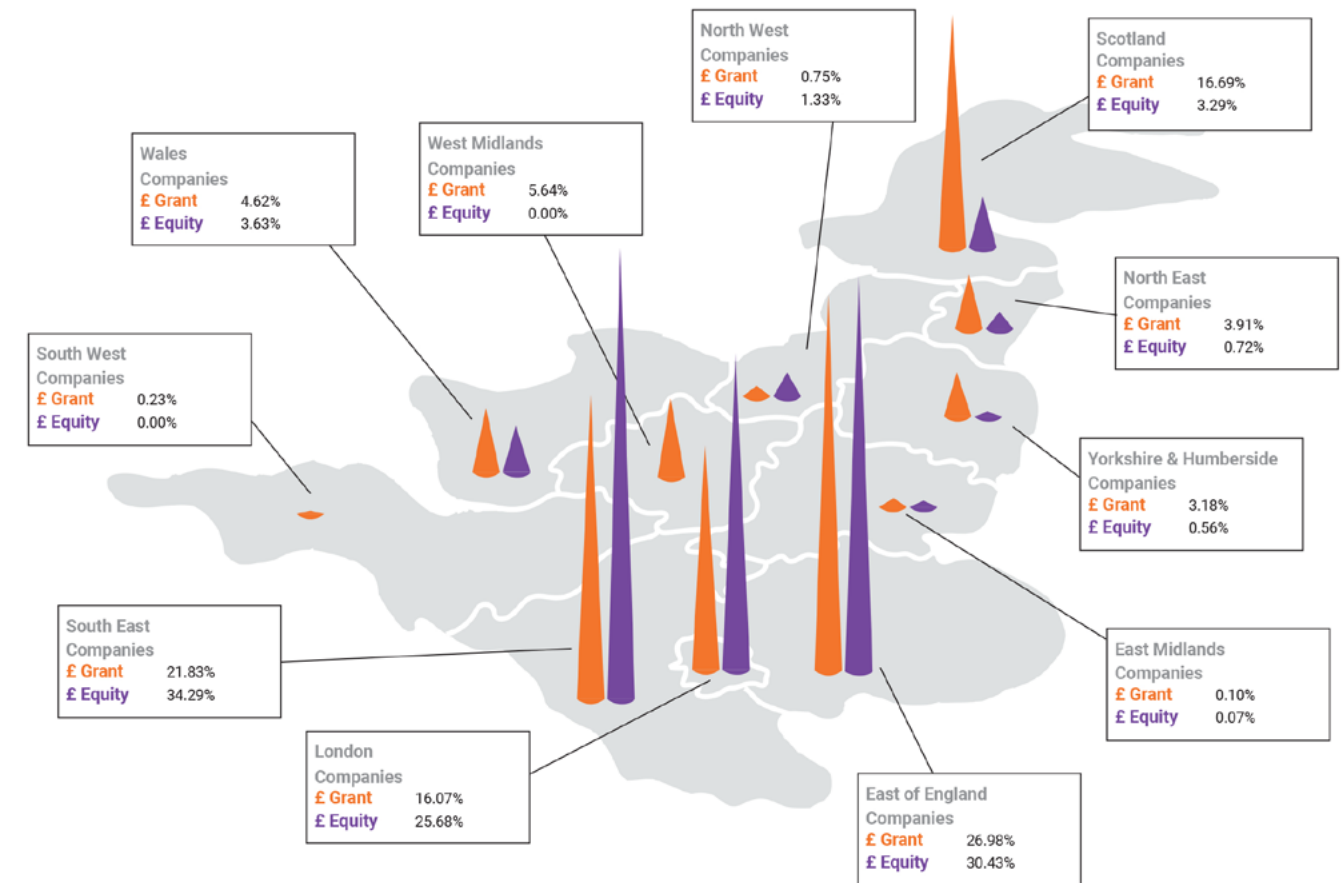


Finance

Total amount raised by Synthetic Biology start-up companies



Percent distribution of equity and innovate grant funding by region



COMPANY SPOTLIGHT

Green Biologics

Green Biologics is a renewable chemicals company focused on developing and delivering new green alternatives for everyday products. Using a technology platform built on both biology and chemistry, exploiting *Clostridium* microbial fermentation. The platform converts a wide range of sustainable feedstocks into high-value green chemicals including n-butanol and acetone, through biochemical synthesis, derivatives for downstream formulations.



- Founded 2003
- Based in Oxford
- 2014 acquired assets of the Central Minnesota Ethanol Co-op, a 21m gallon per year ethanol producer
- Raised \$84m, including £34m debt financing

Investment is heavily concentrated in the South East, East of England and London, with 90% of all private equity and 88% of all funds (equity and grant) raised by companies in these regions. Since all private equity rounds having some level of public sector investment, grant funding is critical to support a regional start-up ecosystem. This appears to be happening in the devolved regions with Scotland and Wales raising, 5% and 4% respectively of the all the funds, significantly more funding than other UK regions outside the golden triangle.

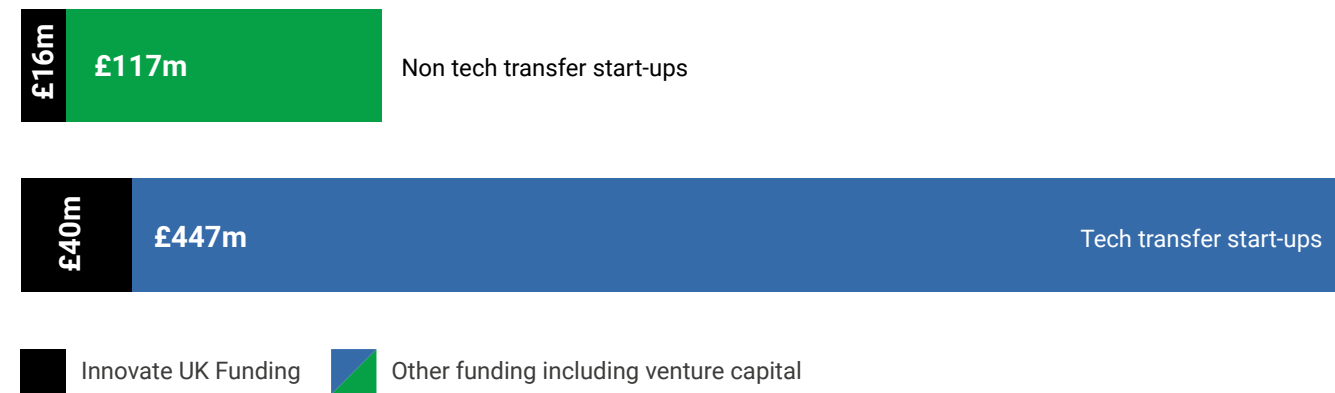
As to be expected, the number of start-ups is significantly higher in regions which are capable of supporting companies with investment. We recognise that numbers of start-ups is no measure of quality or ultimate success. Quality is clearly difficult to measure in early stage start-ups, but a reasonable surrogate for quality is whether other people are prepared to invest money in the business.

90%
of funds raised going to companies in South East, East of England and London



Finance

Funding among tech transfer and non-tech transfer start-ups



From 2001-2016 the amount of funding raised by tech transfer start-ups (£447m) exceeded that raised by non-tech transfer start-ups (£117m). The funding raised by tech transfer start-ups underlines the value of university research and its potential for commercialisation. Government funds distributed by Innovate UK and SynbiCITE for proof-of-concept and development of prototype have also been used to support both tech transfer (£40m) and non-tech transfer start-ups (£16m).

The Accelerator Model

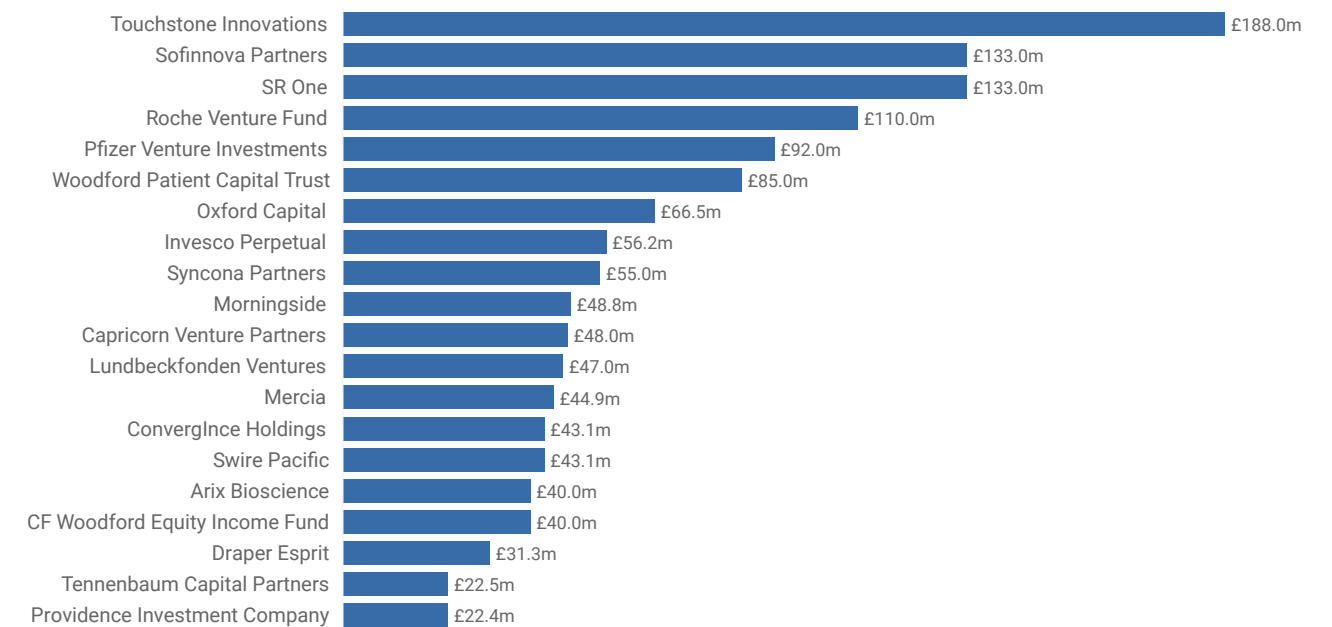
The pace and growth of accelerator programmes across the UK has been exponential in the past few years. There are 163 accelerators across the UK, with more than 45 new accelerators being set up in 2016 alone. There are over 25 accelerators in London, offering early-stage companies the opportunity to participate in typically a 10 to 12-week period that provides training, mentorship and an opportunity to pitch to investors. There are some not-for-profits, but most accelerators take a small equity stake in the start-ups. An accelerator is different than an incubator, which provides office and lab space, training and networks to university spin-outs (tech transfer start-ups) in return for rent. The accelerator model is much more aligned with serving the needs of rapidly increasing the number of non-tech transfer start-ups.

Investors

Private Equity and Venture Capital funding accounted for 40% of all the money raised and was the largest investor in synthetic biology start-ups. Interestingly, amongst the largest investors in synthetic biology start-ups were local, regional and devolved

governments, responsible for 12% of the total funding, eclipsing Angel Investors contribution at 7%. Crowdfunding has also emerged as a new source of funding with two start-up companies raising money on the crowd sourcing finance platform Kickstarter.

Top funders by total value of fundraisings



19% INCREASE IN DEALS
Investment into all UK early-stage life sciences companies is booming. **Seed-stage life science businesses saw a 19% increase in deals**, and recorded £200m investment in 2016.



Conclusions

This survey of synthetic biology start-ups in the UK reveals the extent of the remarkable growth of new companies exploiting recent technological changes, which are transforming the life sciences. These changes, under the banner of synthetic biology, have been catalysed by a confluence of developments in molecular and cell biology, chemistry, engineering, automation, computational modelling and artificial intelligence. This change is transforming how we engineer biology. Start-ups are taking full advantage of these developments by applying synthetic biology techniques to everything from the production of chemicals and biofuels to cancer therapy.

A survey of UK companies engineering biology to create new products and services since 2001, reveals that apart from a slight dip during the economic recession in 2008, the level of synthetic biology start-up formation since 2001 has remained fairly stable. Analysis of this growing sector also revealed the increasing amount of private investment now being directed into UK start-ups.

What is also immediately apparent is the extent of the concentration of synthetic biology start-up activity and investment in the South East corner of the UK. The growth of start-ups in this region is being driven by a new innovation ecosystem, which is nucleating activity in this part of the UK. The availability of academic research excellence

in synthetic biology, entrepreneurial know-how and the managerial experience required to create viable commercial opportunities is attracting an increasing amount of private investment to the sector.

The current surge in investment going into synthetic biology start-ups shows no sign of abating. On the surface everything looks positive, with both the funds raised and the size of the individual deals increasing. This investor optimism is, in part, due to a number of well-received IPOs and mergers & acquisitions across the sector. A note of caution comes with last year's slight decrease in investment and levelling off of the number of deals. There can be no room for complacency. To maintain and increase funding, investors need to see a constant stream of start-ups and entrepreneurs delivering compelling scalable business opportunities.

The role of universities and the synthetic biology research centres in the encouragement of start-up activity is probably more significant because this technology is at the cutting edge, so trends in spin-out activity are worth watching. There is significant variation between the universities with the top few, Cambridge, Imperial College London and Oxford, standing apart from the others.

One challenge all universities are now being faced with is the cultural shift, taking place as more proto-entrepreneurs from these institutions look to create non-tech transfer start-ups. The need for entrepreneurial training for these individuals has never been greater. Some university technology transfer offices have embraced these changes and have already undergone a shift in mission from capturing value for their institutions to creating value for society.



Appendix

Methodology

The criteria for inclusion in the study were:

- Company must utilise synthetic biology/engineering biology.
 - Self-identify as synthetic biology/engineering biology company.
 - Recipient of Innovate UK synthetic biology grants.
 - Spun-out of the synthetic biology research centres.
- The company must be research or product focused, excluding consultants.
- The company must be sufficiently established. Non-operational entities that are companies in name only are excluded.
- Subsidiaries of other companies are also excluded.
- The companies must be based in the UK and incorporated between 2000 and 2016.

Data Sources

- The company data that was used in this report was gathered from various sources, mainly from websites, databases and personal communications.
- The data sources that we searched were:

Sources	Description
Companies House	Companies house online service providing searchable company name and address index
Beauhurst	All financial and investment information was supplied by Beauhurst, the leading provider of rich data on high-growth UK companies
Spinouts UK Project	Listing of spin-outs and start-ups from Universities and HEIs across UK, with information on origins, activity, growth and current status

UK Regions (Office for National Statistics)

Regions of England; North East, North West, Yorkshire & The Humber, East Midlands, West Midlands, East of England, London, South East, South West. Scotland, Wales are Northern Ireland, not subdivided, but listed as regions with the UK.

Industrial Sectors (Global Industry Classification Standard)

Pharma/Biotech companies that produce medicines (biotechnology medicines have a biological basis and pharmaceuticals have a chemical basis).

Tools and Services includes companies involved in drug discovery, development, and production continuum by providing analytical tools, instruments, consumables and supplies, clinical trial services, and contract research services. Including firms primarily servicing the pharmaceutical and biotechnology industries.

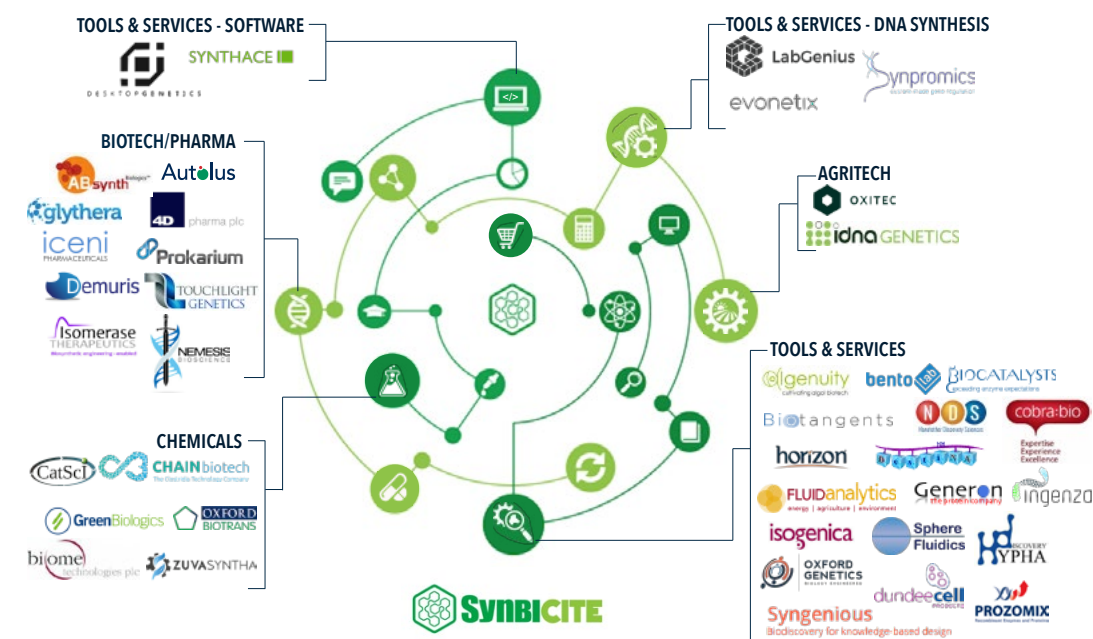
Chemical sector includes producers of commodity, diversified, fertilisers, agricultural, and specialty chemicals. It also includes manufacturers of industrial gases.

Agritech is the use of technology in agriculture, horticulture, and aquaculture with the aim of improving yield, efficiency, and profitability. Agritech can be products, services or applications derived from agriculture that improve various input/output processes.

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Spotlight on UK Synthetic Biology Start-ups



Sectors

Pharma/Biotech

This sector includes companies engineering cells for the development of new pharmaceuticals, medical devices or diagnostics. Examples of companies include: Prokarium (<http://www.prokarium.com>) is developing an oral vaccine using an engineered non-pathogenic strain of *Salmonella* to stimulate the body's own immune system. 4D Pharma Research (<http://www.4dpharmapl.com>) is developing microbiome products for the treatment of inflammatory diseases. Autolus (<http://www.autolus.com>) is engineering T-cells to act as autonomous agents capable of killing tumor cells.

Chemicals

Companies developing novel methods for the production of chemicals used in flavors, fragrances, pharmaceuticals, and other industrial applications. Green Biologics (<http://www.greenbiologics.com>) engineer bacteria to produce chemicals used in paints, adhesives, cleaners and flavors. Oxford BioTrans (<http://oxfordbiotrans.com>) developing new enzymatic process technologies that yield high-value chemical compounds.

Agritech

Companies developing synthetic biology services, like iDNA Genetics (<http://www.idnagenetics.com>) and others providing solutions to combat plant and animal diseases and pests. Oxitec (<http://www.oxitec.com>) developing genetically modified insects to control the spread disease or pests that damage crops.

Tools & Services

Core products and technologies including standardised DNA parts, synthetic genes, computer-aided design, automation operating systems and new tools entering the marketplace to facilitate the production of enabled products. This sector can be sub-divided into a number of specialist sub-sections.

DNA Synthesis

Companies whose core function is providing synthesis DNA as a service. Synpromics (<http://www.synpromics.com>) designs and develops proprietary synthetic promoters regulating genes at the precise levels required to elicit a specific physiological function, in a particular cellular environment. Another startup company, Lab Genius (<http://www.labgeni.us>) designs and manufactures synthetic DNA libraries used in antibody engineering, novel biocatalyst development and functional nucleic acid design.

Organism Engineering

Companies in this sector are developing platforms and processes to enabling the rapid scaling of metabolic engineering to generate optimised cell factories for organic molecule production. Ingenza (<http://www.ingenza.com>) is developing the technology to enable the rapid engineering of microbes to produce high value chemicals such as those used in flavours and fragrances.

Software

Companies building software products that facilitate the design and build of custom DNA sequences. Desktop Genetics (<https://www.deskgen.com>) has created a platform for CRISPR gene editing. Synthace (<http://www.synthace.com>) has developed an operating system that facilitates the automated design and optimisation of synthetic biology protocols.



Spotlight on UK Synthetic Biology Companies

Company	Sector	Investors	Intellectual Property
4D Pharma Research http://www.4dpharmacplc.com	Pharma/Biotech	Woodford Investment Management, Invesco Asset Management Limited, Lansdowne Partners, Aquarius Equity Partners, Genomia, Scottish Enterprise	Yes
Absynth Biologics http://www.absynthbiologics.co.uk	Pharma/Biotech	Fusion IP, SPARK Impact, Biomedical Catalyst Fund	Yes
Algenuity http://www.algenuity.com	Tools & Services	Private	No
Autolus http://www.autolus.com	Pharma/Biotech	Syncona, Woodford Investment Management, Perceptive Bioscience Investments	Yes
Bento Bioworks https://www.bento.bio	Tools & Services	KickStarter, SynbiCITE	No
Biocatalysts http://www.biocatalysts.com	Tools & Services	Private	Nothing active
Biome Technologies http://www.biometechnologiesplc.co.uk	Chemicals	Innovate UK	No
Biotangents http://www.biotangents.co.uk	Tools & Services	Scottish Enterprise, SynbiCITE	No
CatSci http://www.catsci.com	Chemicals	Innovate UK	No
Celbius http://www.celbius.com	Tools & Services	Innovate UK	No
Chain Biotech http://chainbiotech.com	Chemical	Innovate UK, SynbiCITE	No
Cobra Biologics http://www.cobrabio.com	Tools & Services	Innovate UK	No
Customem http://customem.launchrock.com	Tools & Services	Innovate UK, SynbiCITE	No
Demuris http://www.demuris.co.uk	Tools & Services	Innovate UK	No
Desktop Genetics https://www.deskgen.com	Tools & Services: Software	Vitro Group of Spain, Old College Capital, SIB, Private, Boundary Capital, Illumina, IQ Capital Partners	No
Destina Genomics http://www.destinagenomics.com	Tools & Services	Scottish Enterprise	No
Dundee Cell Products https://www.dundeeceellproducts.com	Tools & Services	Innovate UK	Nothing active
Evonetix http://evonetix.com	Tools & Services: DNA Synthesis	Cambridge Consultants, Amadeus Capital Partners	Yes
Fluidic Analytics http://www.fluidicanalytics.com	Tools & Services	IQ Capital, Cambridge Enterprise Seed Fund, (Parkwalk Advisors), Draper Esprit, Amadeus Capital Partners, Cambridge Innovation Capital	No
Generon http://www.generon.co.uk	Tools & Services	Innovate UK	Yes
Glythera http://www.glythera.com	Pharma/Biotech	North East Technology Fund, IP Group	Yes
Green Biologics http://www.greenbiologics.com	Chemicals	Capricorn Venture Partners, Innovate UK, Sofinnova Partners	Yes
Horizon Discovery https://www.horizondiscovery.com	Tools & Services	U of Cambridge Enterprise Seed Fund (Parkwalk Advisors), Cambridge Enterprise, MVM Life Sciences, DJFEspirit LLP, Roche Venture Fund, Providence Investment Company, Individuals	Yes
Hypha Discovery http://www.hyphadiscovery.co.uk	Tools & Services	Innovate UK	No
Iceni Pharmaceuticals http://www.icenipharma.com	Pharma/Biotech	Innovate UK	No
iDNA Genetics http://www.idnagenetics.com	Agritech	PBL	No

Company	Sector	Investors	Intellectual Property
Ingenza http://www.ingenza.com	Tools & Services	Innovate UK	Yes
Isogenica http://isogenica.com	Tools & Services	Innovate UK	Yes
Isomerase Therapeutics http://www.isomerase.co.uk	Pharma/Biotech	Innovate UK	Yes
Lab Geniis http://www.labgeni.us	Tools & Services: DNA Synthesis	Private, Innovate UK, SynbiCITE	Yes
Nanotether Discovery Sciences http://www.nanotether.co.uk	Tools & Services:	SynbiCITE	Yes
Nemesis Biosciences http://www.nemesisbio.com	Pharma/Biotech	Innovate UK	Yes
Oxford BioTrans http://oxfordbiotrans.com	Chemicals	Imperial Innovations	Yes
Oxford Genetics http://www.oxfordgenetics.com	Tools & Services	Innovate UK, Mercia Fund Management	Yes
Oxitec http://www.oxitec.com	Agritech	East Hill Advisors, Oxford Capital Partners, Oxford University	Yes
Prokarium http://www.prokarium.com	Pharma/Biotech	Private, Innovate UK, SynbiCITE	Yes
Prozomix http://www.prozomix.com	Tools & Services	Innovate UK	No
Solentim http://www.solentim.com	Tools & Services	Innovate UK	Yes
Syngenuous http://www.syngenuous.com	Tools & Services	SynbiCITE	Yes
Sphere Fluidics http://www.spherefluidics.com	Tool & Services	24 Haymarket, Parkwalk Advisors, London Business Angel, Innovate UK	Yes
Synpromics http://www.synpromics.com	Tools & Services: DNA Synthesis	Calculus Capital	Yes
Synthace http://www.synthace.com	Tool & Services: Software	Sofinnova Partners, SOS ventures, Innovate UK	Yes
Touchlight Genetics http://www.touchlight.com	Tools & Services: DNA Synthesis	Private, Innovate UK	Yes
Zuvasyntha http://www.biosyntha.com	Chemicals	Innovate UK	Yes





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