UK BioIndustry Association

A vision for the UK life sciences sector in 2025

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Executive summary

The UK BioIndustry Association (BIA) has been working over the last year to help shape the future of the UK biotech industry. We represent innovative, predominantly healthcare firms who collectively are responsible for 90% of medicines in clinical development in the UK. Now is an exciting time here, with many promising 'green shoots' emerging after the hard years following the dot-com crash and the financial crisis, which impacted on investor risk appetite for the life sciences sector. Hard work by many stakeholders has given real momentum to the sector, with a number of recent Initial Public Offerings (IPOs) to celebrate, promising patients hope.

Critical to this has been the strong support of government in creating the funding, capability and fiscal environment to nurture early stage innovation. Innovate UK's Catapults and the Biomedical Catalyst (BMC), funded by Innovate UK and the Medical Research Council (MRC) together are the best known of these, but the reforms are many, and come from across government and funders.

With that success in mind, and as we head into a new parliament, we are setting out an ambitious vision for 10 years hence. Biomedical research takes decades to achieve impact. By setting out a vision for two parliaments hence we hope to unlock the excellent science in our country for the benefit of humanity.

Our vision is to "Build the Third Global Cluster". The vision we share is of a vibrant world leading cluster, of the size and scale of Greater Boston today, as befits our great academic system. It will retain its distinct identity, be forward thinking in its priorities and be focused but mature further to drive global impact.

From that vision flows five ambitions for 2025:

1. The UK will be delivering global benefits to humanity, especially via improved health
2. We will be distinct and differentiated, building off the UK's unique health assets and science capability
3. We will build a thriving, well-structured commercial innovation pyramid from large cap, through mid-cap to innovative start-up such that:
    - >Three top 10 pharma have located their HQs to the UK (at least one more than today)
    - All top 10 pharma are actively sourcing deals here and have opened Business Development (BD) offices
    - We have a strong tier of mid-size companies ready for global success
    - We have a globally competitive support services sector surrounding the innovators
4. Our cluster's ability to build, attract and retain global management talent is second to none
5. We are Europe's clear leader as a biotech hub, and widely acknowledged to be in the global top three

The potential health and wealth prize from the realisation of this vision is huge

To size the prize for this vision, we benchmarked as best we could the UK biotech sector to Massachusetts and California, the two global leaders. We normalised the outputs of these clusters to not-for-profit inputs into basic biomedical research. If built by 2025, such a cluster would:

- Take four times as many drugs and other innovations into clinic and to patients
- Attract private investment of £2.9bn per annum. This is £2.6bn p.a. more than today
- Build about ~130 more clinical stage drug companies (and CEOs / teams) than today
- Create 30,000 to 60,000 more direct, high skill jobs than today, with a broader halo
- Create a direct salary pool / income tax-base £5bn to £10bn p.a. bigger than today, again with a broader economic halo

We look forward to working with the broader community to shape this vision, and to starting the debate as to how we can best get there.

The current performance of the UK biomedical landscape:

OVERVIEW

Area	Basic Research	Concept development and testing	Preclinical development
Description	Fundamental, hypothesis led research leading to breakthrough in our scientific understanding of biology and diseases	Initiation of translation via concept development, focused experimental and market need testing and often patent development	Formal steps required to enter trial from regulators such as toxicology, good manufacturing practices (GMP) and animal model validation
Working well	• **The world's most productive large biomedical basic science base** on a dollars to citations basis	• **BMC & MRC confidence in concept**, for the later parts of concept testing and preclinical. These have transformed the system for the better, and unlocked our success • **Cancer Research UK (CRUK)'s drug development office** and the **Cell Therapy Catapult** that provide "one-stop shops" of early translational expertise in their specific areas that can turbo-charge translation	
Could be improved	• While much improved **a gap remains vs. US academics to see value beyond papers** and so initiate translation with timely patents	• Funding streams for **rapid exemplification** to expand patent • **Expert input into commercial potential** • **Detailed "killer experiment" design** and quality – the right models, controls & good laboratory practice (GLP) to enable success	• **Funding streams for biological GMP** – more expensive and not easy to fund today • **Sample access from the National Health Service (NHS) challenging**, especially for historically annotated samples
Score	●●●●●	●●●	●●●●

KEY UNDERLYING ENABLERS

Area	Knowledge transfer	Academic incentives	Cluster strategy
Description	Transfer of information across the academic interface on unmet need and potential new technologies and solutions	Frontline incentives that drive day to day behaviours, such as tenure, lab funding and recognition	Strategic support to drive "importance of place" (cluster theory) into practice with focused investment both in science and infrastructure
Working well	• Average UK Technology Transfer Office (TTO) as good as US average • Sustained **investment in knowledge transfer infrastructure**	• **Citation based incentives on funding and tenure that drive great science** • Research Excellence Framework (REF) and its "impact" framework (at least for universities)	• **Cambridge, which is near critical mass** required in product innovation in both private and public sector • **Northern Health Science Alliance (NHSA) as an emerging "clinical cluster"**
Could be improved	• **Real variability in TTO performance**, and a clear gap to US best • Few mechanisms to identify unmet market needs and feed them back to academics and their funders	• Sustainable academic career paths and **broader recognition for translational scientists**, who generate less citations • Individual Principal Investigator (PI) accountability for impact • Time for impact, e.g. 4+1 working	• **Funding behaviours that "divide the cake"** rather than "focus on the world class" • **Better mapping of "what is world class and close to scale"** to allow strategic investment
Score	●●●	●●●	●●●●

●●●●● **= World class**

a snapshot

	Early clinical	Late clinical	Market uptake
	"First in man" safety studies, and early clinical trials to optimise dosing and identify relevant patient groups for further development	Pivotal studies that provide regulators and payers with the efficacy and safety evidence to license and reimburse a new therapy or technology	Equity funding to allow global launch, and local uptake processes that create a home market for world class local technology
	• Combination of **BMC and corporate venture capital (VC)** have opened up funding • **Some strong specialist early trial units** within the NHS	• **The National Institute for Health Research (NIHR) Office for Clinical Research Infrastructure (NOCRI) has turned around "time & target"** in trials • **World leading health economic research** • **World leading adaptive trial design** e.g. in cancer & Alzheimers	• **Established Health Technology Assessment (HTA) for drugs via National Institute for Health and Care Excellence (NICE)**, with integrated uptake processes via drugs funding rules and prescription behaviours • **Various data assets in the NHS**, (e.g. diseases registries), that will be important for "database driven R&D" and precision medicine
	• **Funding gap for "high commercial risk" phase II** studies: tropical disease, vaccines and "high attrition risk" disease areas like novel drug targets	• **National recruitment paths for biomarkered patients**, given patchy NHS molecular testing - essential to precision medicine • **Hospital level ethics still cumbersome** (but changes being piloted by Genomics England)	• **Non-drug NHS uptake processes:** for diagnostics and devices, uptake is negotiated by hospital and so complex and slow • **Growth equity**: European vs US capital markets relatively unfavourable to biotechs
	●●●●	●●●	●●●

	Management talent	Fiscal climate	Finance
	World class commercial biotech management that can grow a company from foundation to commercial maturity	Mature government life sciences strategy	A small pool of expert investors in a global finance centre (London) that largely ignores the sector
	• Some **depth in VC-backed companies** in the south, with repeat entrepreneurs • Some specialist skills from pharma through recent lay-offs & research and development (R&D) reorganisations	• **R&D tax credit system** • **Low Corporation Tax** • **No withholding tax** • **Enterprise Investment Scheme (EIS) and Seed Enterprise Investment Scheme (SEIS) schemes for investors**	• Some expert **angel and VC funds** • Some innovative corporate venture
	• But two clear gaps, firstly in **bench depth to run 10x more biotechs** and, • Secondly in **scale-up experienced** executives	• Unlocking pension fund money as a source for investment	• Low deal flow means few analysts and market makers in capital markets • Lower liquidity than other markets
	●●●	●●●●	●●

Where we are now and how we build from it

In summary, we are building from emerging success in biomedicine, particularly the great fiscal climate in the UK, the BMC and the recent crop of IPOs. We are also starting to tackle complex issues like regulatory reform and innovation in the NHS. As an example, the turnaround in commercial trial performance is to be applauded. Overall, the system is feeling brighter than it has for many years, and more joined up.

However, compared to our vision, there remains much still to do. Health innovation is a global business – only the world's best ideas win. We must be at the top of our game. We must also make these improvements in a time of austerity. As a result, we will need to focus and be more strategic in how we develop the ecosystem. **We can only do that effectively if we manage the life sciences ecosystem in an integrated way for health, science and wealth creation**. That will require new ways of working that break down traditional boundaries between the private and public sector. The BIA, representing innovative Small and Medium Size Enterprises (SMEs) and biopharma, would like to work more closely with other stakeholders to make that happen.

National strategic resource allocation for innovation requires four things:

- An understanding of the **needs** that will create new markets in 20 years' time
- An understanding of what **assets** we have in the UK that are truly world class and can be brought to bear to solve these needs, and more effectively than the global competition
- **Tailored, economic solutions** to help those assets unlock their global potential
- **A process for making difficult trade-offs** against these opportunities that makes choices rather than spreading the investments too thinly to succeed

The private sector, in partnership with others, has an important part to play against each of these. We understand markets and unmet need. We are constantly focused on creating differentiation through great science. We know that we are playing a global game as each of our members faces specific competition in their niche from other clusters. We can look at assets held by other stakeholders and see their hidden potential. The BIA offers these skills to other stakeholders to help make this cluster globally unique and successful.

As an example, the data assets in the NHS are globally important to a major theme for future innovation: clinical big 1 data. Its commercial value lies in driving higher productivity "database driven R&D" for pharma. Managed correctly, these assets could both be a source of income to the NHS, and unlock non-commercial care improvement innovation. We look forward to the role that the Precision Medicine Catapult can play in advising how the UK can best unlock their potential.

In medical research, the single disease charities have an important role to play in innovation. Organisations like Fight for Sight and CRUK are already leading on this. Generally, they have deep understanding of both patient needs and the science that can serve those needs. They also have a unique convening ability that can break down silos. Their involvement in broader agenda setting and focus on innovation for patient benefit; and the patients themselves that drive this; should be encouraged more broadly.

We know that the prize is large, but what sorts of changes are needed to make this happen? We propose 10 'themes for change'. We present this list with some trepidation. The biotech ecosystem is complicated, our diagnosis likely incomplete. As a result, we see this list only as a place to start a dialogue with other stakeholders. We strongly believe that the action plan for this sector has to be co-created with cross-sector and cross-party input. Unless it is co-created in that way, it is unlikely to catalyse durable change and drive patient benefit.

10 themes for change

1. **10x more strategic**. Health innovation is a global race, and resources are limited. We can't be good at everything. For humanity's benefit, we need to strategically focus on the unmet needs that our research base is uniquely well placed to solve for the world.
2. **10x more focused on patient benefit**. Only differentiated innovation, solving true unmet need and with favourable health economics can help patients. It is our duty to deliver that.
3. **10x more growth equity**. Despite recent IPOs, the London markets are less favourable than NASDAQ for biotech. That constrains venture investment, and results in premature exit to global pharma of promising technology, limiting the impact of our sector on local jobs.
4. **10x more academics and clinicians willing to try**. Without a middle-tier commercial biotech sector, the main source of Intellectual Property (IP) for future UK innovation will be academia and the NHS. We must continue to encourage them to try, but be more sophisticated about our means.
5. **10x more willing to fail**. Fast failure is cheap failure, and biotech is a high attrition sector. Coupled with increased willingness to try must be increased willingness to fail. That means encouraging the earlier "killer experiment", and safety-nets for those who try and "fail well".
6. **10x better knowledge transfer**. Today our TTOs are often seen as barriers to translation. However, their performance is a product of policy, funding and environment. We must stop incentivising our TTOs by income. We must proactively encourage more industry input into academia. Knowledge exchange at the edge of academia must be two-way, both for the "push" of new science, and the "pull" of unmet patient and industry need.
7. **10x better concept testing**. The skills, commercial insight and experiments to drive effective concept testing are complex, disease specific and can make all the difference to the uptake of great science so that it will benefit patients. We must invest to make this happen better.
8. **10x more NHS engagement**. The NHS should be a unique source of innovation, and a unique partner to innovation. Despite improvements, for instance in clinical trial performance, it is still generally a barrier to both. We need to continue to engage the NHS on innovation, both as a source of potential revenue to the service (e.g. its data assets) and in making the uptake of innovation more efficient to bring effective innovation to patients faster.
9. **10x more biotech management talent**. If we are to reach our goal, we need hundreds more clinical stage management teams. We will need a sector-wide talent plan to close this gap.
10. **10x more celebration of success**. The path to patient benefit is long and complex. We need to celebrate our successes along the way so as to explain the benefits of our sector to society at large and governments of whatever hue.

Our vision for UK Cluster 2025

Based on input from the BIA Board and broader experts, we have developed this proposed 2025 vision for the UK biotechnology ecosystem. As well as their expert input, we also consulted previous sector reports, policy and academic papers on biotechnology clusters.

This is a conceptual hypothesis that needs debate, challenge and revision. It is presented here to give the broader community something to react to and improve from. It aims only to give a flavour of some of the arguments supporting the vision and what the vision is supposed to imply.

A date in 2025 was chosen as having sufficient runway for the UK to make substantial change to the life sciences sector's innovation performance. Clearly, being at least two parliaments away, more work is needed to define the three and five year milestones and policy objectives to reach that goal.

Given the emerging vision, we have also benchmarked the gap between the UK today and the top US biotech clusters, in terms of science, investment, health and wealth.

WE LOOK FORWARD TO REFINING THIS VISION WITH OUR MEMBERS AND THE BROADER COMMUNITY

A vision for the UK in 2025 in biotechnology

Below is a simple summary of our vision for the UK in biotechnology. Over the next pages we aim to take apart that vision, and explain why we have crafted it as we have.

Our vision: to build the UK as the third global biotech cluster

1. Delivering obvious benefits to humanity, especially via improved health
2. Distinct and differentiated, built off the UK's unique health assets and science capabilities
3. Thriving, well structured innovation cluster: strong pyramid from large cap through to mid-cap to innovative start-up with:
    - >three top pharma headquartered (HQ-ed) in the UK
    - All top 10 pharma sourcing deals here
    - Strong tier of mid-sized companies
    - Vibrant support services sector
4. Our cluster's ability to build, attract and retain global management talent is second to none
5. Europe's clear biotech leader, and widely acknowledged to be in the global top three

1. Obvious benefits to humanity, especially via improved health

Many of our members and experts commented that this was "obvious", or "a given" as we developed this vision. However, it is a message often lost in the day-to-day running of the system. As a sector, our members can often seem very financially focused given the expense and many funding rounds needed to get a health innovation to market. This perception is also increased by the sector's historic focus on "successfully exited CEOs".

This statement has the broadest appeal across stakeholders and should be much more central to the sector's overall communication plan. It appeals positively to the general public, as patients, as taxpayers, and as supporters of medical charities. It is the strongest argument against anti-science lobby groups. It motivates NHS clinicians and staff, as well as governments, investors and company employees. We can all identify more closely with patient success stories than with more abstract arguments about economic benefit and wealth creation.

As a result, this message is central to the vision. This is the message that most unifies the sector and will best help build the alliance to drive change. All of us have a role in increasing the sector's focus on this message, from those of us writing pitch-sheets for new biotechs to those of us lucky enough to have had successful clinical trials that have helped patients.

2. Distinct and differentiated, built off the UK's unique health assets and science capabilities

Health innovation requires world class capabilities. Given the depth of funding required, and our relative scale versus the US, it is unlikely that we can win at everything. As a result, we should focus where we have differentiation – assets and capabilities that are better than other systems.

That differentiation can take many forms. It could be in our large and strong hospitals – for instance the Christie in Manchester is Europe's largest cancer hospital, and Glasgow West one of the largest in cardiovascular. It could be in NHS data assets, such as the disease registries. Often innovation is found in our world leading bioscience service sector that delivers to the globe. It could be in hidden assets within industry (be it pharma or tech) that can be spun-out to improve health. It can also be in the great science in our research-led universities.

We need to map these assets and work out what we have that is world class. Such information doesn't readily exist today. Other systems, such as Canada, have undertaken systematic reviews of their assets to drive their wealth and health strategies. We should do the same, and do so across the academic, private and health care sectors.

3. Thriving, well-structured cluster with a strong pyramid from large cap through to innovative start-up

Successful technology clusters consist of a pyramid of companies, from the many very small to the few very large. They are engaged in the creative destruction that drives disruptive innovation. Great ideas come, are tested and either fail or become tomorrow's market success stories. Some will achieve market success independently (mid-size companies), others via acquisition or partnering with the big companies.

This ambition will involve reshaping the pyramid in the UK. At present Britain's biomedical estate consists of lots of small companies, two to three large and a very empty middle tier. There are many reasons for this, especially various public equity market challenges. However, one of the hallmarks of success will be the evolution to a more balanced pyramid.

This lack of a middle tier makes effective translation harder in the UK than elsewhere. Such companies play an important role in hunting out good ideas in their specialism, especially from academia. Where they exist, such as Almac and Randox in diagnostics in Northern Ireland, they change the innovation dynamics in that local system. In that case, the local NHS pathology infrastructure is very open to and integrated with diagnostic development because of its long association with these companies.

Our vision for a thriving UK cluster would see the following in 2025:

>Three top pharma HQ-ed in the UK (one more than today).

Pharma have pulled back in terms of R&D jobs from the UK over the last decade. Even locally born Shire moved its HQ to Ireland. We must turnaround this trend if the UK is to build a successful cluster. By 2025, either one of our strong tier of mid-size companies needs to have gone global, or the cluster is such a source of innovation that a global pharma has relocated here. In an ideal world, we would see both occur, so that there are clear organic growth success stories and a clear signal of the international performance of the cluster from inward investment.

All top 10 pharma sourcing deals here.

There is a trend in SME drug innovation towards "build and flip", where IP is developed often by venture to the point that it is a low attrition risk for pharma, who then buy the company. This naturally replenishes pharma's pipelines. Some forward-thinking global majors are investing in deal sourcing here, such as J&J Innovations. But not all, and of those who come to scout here, few get beyond the southeast. By 2025 we should have built enough innovation at the bottom of the pyramid that global pharma not only want, but have to be here to compete, and have built their European BD teams in the UK.

Strong middle tier of mid sized companies.

In addition, if we are to build jobs and talent we will need some of those SMEs to scale and go global. These scale-up success stories will form the backbone of a strong middle tier.

Surrounding these innovators will be a vibrant support services sector from Clinical Research Organisation (CRO) to Contract Manufacturing Organisation (CMO).

It may well focus on more premium niches such as flexible, advanced therapy manufacturing, not bulk generic small molecule. Or in contract research, rational drug design and niche disease-specific phenotypic screening. These will be innovators themselves, strong enough to win business from abroad and will be a net exporting sector as a result. Without winning companies in these service sectors, the jobs halo will be limited, and our sector will not build the skills base it needs to compete.

We will rely on Darwin, not national champions in building this pyramid. High tech innovation clusters rely on creative destruction as innovation cannot be fully planned. Systems that have tried to back national technology champions (France in telecoms, media and technology (TMT), Germany & Singapore in biotech) have generally failed. Market based systems generally do high tech innovation better, as long as policy makers understand the limits of the efficient market and build the right policy support.

Government will have a key role, but it will be in getting the environment and incentives right, not picking winners. Even the Commonwealth of Massachusetts, in the market-focused USA, invests heavily in creating the right ecosystem for the Boston cluster. Via Mass Life it has committed to $1bn of tax payer investment in the sector over a decade to keep the sector globally competitive. That investment pays off handsomely in terms of Gross Domestic Profit (GDP) and tax growth.

4. Our cluster's ability to build, attract and retain global management talent is second to none

The sector faces critical challenges in securing bright, skilled staff with entrepreneurial flair and leadership élan. These skills are critical for successful biotech given the complexity of the development cycle and its funding needs. Deep functional expertise is not enough. We need leaders who combine a depth of related skills and expertise in a single field, with the ability to collaborate across disciplines with experts in other areas and general management skills.

Some of this talent exists today, and some is world class. However, we need an order of magnitude more to build the cluster – as the benchmarking on clinical stage companies shows. We will need a national talent plan that combines growing and retaining the talent we have with proactive, targeted poaching of talent from abroad. The global alumni of our top universities and funders could be a critical, and under-used, resource to fill this gap.

Achieving the vision relies on attracting and retaining the very best, globally, to the UK cluster. That talent wants a sustainable, interesting career in a high attrition sector. As a result, we need to offer it three things:

- **Global dynamism, innovation and learning**
  Biotech is a rapidly expanding and transforming field, which needs exceptionally creative and capable individuals with a passion to compete on an international basis and continually improve
- **Job flexibility**
  The current UK biotech jobs market is small and illiquid: changing jobs is very risky, and often involves unacceptably high costs for mid-career professionals. As the cluster succeeds, there will be many more choices available for highly skilled staff – you can change jobs without moving house and changing schools
- **Porous walls between industry, the NHS and academia**
  We need to create revolving doors between industry, the NHS and academia to get the cross-fertilisation of skills and ideas essential for translation

5. Europe's clear biotech leader, and acknowledged to be in the global top three

The North American experience shows that even with substantial national and state investment, only two biotech clusters have reached critical mass (Boston and the Bay area). As a result, it is unrealistic to imagine that all the European potential clusters will make it. Given the US experience, one, perhaps two, will get there in the next ten years.

The UK is currently at the forefront of European biotech. To maintain and enhance this position the development of a UK innovation cluster is at the heart of the vision. Realistically, the centre of gravity for this will be in the southeast, and will have a geographically broad hinterland of support services. Talent and IP are key to biotechnology innovation. Both are highly mobile, and we should use European freedom of movement to our advantage. There is much to be learnt from best practice from across the UK, with innovative ideas on clustering emerging from policy, academic, political and financial communities in Wales, the North West, and Scotland, each evolved to the needs of their geography but also with much that can be adapted for broader success.

Such a cluster has the potential to become the undisputed leader of biotech in Europe. That leadership should span technology innovation, specialist contract, regulatory innovation and manufacturing. It should cover capital markets, specialist deal advisory and other professional services.

The prize if Britain could reach Boston

Economic benchmarking allows an approximate assessment of the prize if the UK could catch up with Massachusetts (MA) or California (CA). We have chosen metrics in science productivity, private investment, innovations reaching patients in clinic and wealth creation through jobs[1].

We have normalised the benchmarking to basic not-for-profit R&D spend in the biomedical sciences[2]. The rationale for this is that basic research spend "pump-primes" serendipitous innovation through the discovery of new science that then drives the rest of the system. This methodology ignores basic research and discovery in industry. However the broad rationale seems reasonable when thinking about innovation timescales over decades led by new science.

The main insights from the benchmarking are that **the UK biotech cluster, if running at the scale and success rates of Massachusetts or California, would:**

- Attract **private investment of £2.9bn per annum**. This is £2.6bn p.a. more than today
- Build **~130 more clinical stage drug companies** (and CEOs / teams) than today
- Take **~four times as many drugs into clinic** (and presumably to market)
- **Create 30,000 to 60,000 more high skill jobs**, with a broader halo effect
- Create a **direct salary pool / income tax-base £5bn to £10bn** p.a. bigger than today[3]

Benchmarking the UK's potential in biomedical innovation

		UK	MA	CA	UK in 2025
The Science	Life sciences research input, £bn p.a. (non-business, average 2010-12)	3.3	1.8	2.9	3.3
	Biomedical papers, by author location, 2013	75k	35k	50k	59k
The Money	VC investment, £bn (average 2010-12)	0.10	0.61	0.92	1.06 (£1bn more)
	IPO capital raised, £bn (average 2010-12)	0.02	0.03	0.22	0.25 (£0.2bn More)
	Follow-ons, £bn raised (average 2010-12)	0.14	0.71	1.53	1.55 (£1.4bn more)
	Total private money, £bn p.a.	**0.25**	**1.45**	**2.67**	**2.86 (£2.6bn more)**
The Clinic	# private drug biotechs at early clinical (Phase I and Phase II, 2012)	18	23	50	51 (~30 more)
	# Listed pre-commercial biotechs & medtechs (2012)	35	48	145	134 (~100 more)
	Total clinical pre-commercial companies	**53**	**71**	**195**	**185 (130 more)**
The Wealth	Total direct jobs, (2012, k)	91	54	125	124 (33k more)
	Averages wages (£k, 2012)	39	74	66	68 (73% higher)
	Total Salary pool, £bn	**3.6**	**3.9**	**8.2**	**8.5 (UK £5bn bigger)**

[1] Data on industry funding to universities would have been useful, but no systematic source was found.

[2] To match to US state level NIH and charity data, UK funding only covered AMRC, BBSRC, MRC, NIHR and Innovate UK. EPSRC funding has not been included as comparable state level breakdowns for the US engineering & physic funders to the biotechnology sector is not available.

[3] The direct industry sectors sampled are only about half of the total sector – see detailed methodology at Appendix 2

The performance of the UK system today

We have used our Board and experts to assess the performance of the system today, so as to help policy makers better understand where we are, and what we need to do. Below is a summary.

		Capability	Funding
Academic Culture	1. Healthy academic biomedical science ecosystem	*****	*****
	2. World-class concept development	****	*****
Translation	3. Early, effective concept testing in the academic setting	***	****
	4. Pre-clinical development	****	****
	5. Clinical proof of safety / concept (Phase I and II)	****	***
Uptake	6. Late clinical & outcome research (Phase III / IV)	****	**
	7. Patient uptake in UK	***	
Enablers	A. Knowledge transfer effectiveness	***	
	B. Academic incentives that align to translation	***	
	C. Cluster strategy	****	
	D. World class "commercial" biotech management	***	

******* = World class**

Nine pain points in the system today

1. Academics in the UK patent and initiate translation less than global leaders
2. Concept testing is under-funded, the capabilities scarce and siloed
3. Translational awards struggle on high cost GMP and clinical proof of concept
4. Late stage funding is shallow relative to the US. This has a knock-on effect throughout the system by making venture funding in the UK less profitable and so less available.
5. The NHS seems to work against innovation, from trial bureaucracy to uptake processes
6. UK academic incentives overly prioritise "ivory tower" behaviours (e.g. citations and grant chasing) over "real world" impact
7. Technology transfer needs to be improved
8. UK is struggling to build and retain enough commercial biotech talent (the talent follows the money to the US, especially mid-career)
9. System fragmentation, complexity and lack of overall impact strategy

Detail on the nine pain points in the system

1. Academics in the UK patent and initiate translation less than global leaders

Patents are critical to biomedical innovation, but not for academic citations. There has been progress in getting UK academics to patent strategically, but our researchers still under-patent. As an illustration, the US biomedical system generates 182 triadic patents[4] per $bn of inputs. The UK only 127. A Wellcome Trust briefing document also references survey data which shows that UK academics are about half as likely to patent as their counterparts in a top US cluster, with nearly a third of British respondents saying that their decision was based on the need for publications "to drive grants or my career[5]".

2. Concept testing is under-funded, the capabilities scarce and siloed

Good concept testing is a multi-disciplinary activity with a deep need for pharma insight, both on market opportunity and experimental design. Experts interviewed in CROs, pharma and venture were especially damning of the capabilities in the UK's academic system to design and execute the right "killer experiment", or even to ask for input as to what would be relevant to a downstream IP buyer.

3. Translational funding struggles on high cost GMP and true clinical proof of concept

The introduction of BMC is, as intended, "bridging the valley of death". However, two gaps remain. Pre-clinical GMP for biologics costs around £2m, around five times higher than simple small molecule GMP. This is often beyond the capacity of the relevant award funds. The second is a Phase II funding gap for "true clinical proof of concept". It is possible to get to about Phase IIa today in the UK using a combination of funding sources and some creativity. However, that is often not enough to convince sceptical industry buyers (especially on novel technologies / unvalidated targets), who often want a randomised, phase IIb trial costing tens of millions before investing.

4. Late stage funding is shallow relative to the US. This has a knock-on effect throughout the system by making venture funding in the UK less profitable and so less available

Late stage trial financing typically comes from big pharma or listing on the public markets. AIM is seen as a relatively unfriendly market for biotech listings given its low expertise depth and liquidity. Auction theory suggests a market with fewer buyers will get lower prices. This is the experience of venture firms with their UK portfolio companies with no consistently open path to the public markets for research stage companies. Prices are typically 30-40% lower than for similar US assets. This in turn reduces venture profitability and consequently the availability of venture capital in the UK. As a result it disadvantages the entire UK biotech sector. One could argue the public markets are structurally broken, as policy reform alone cannot create the necessary self-sustaining ecosystem of independent analysts, specialist cornerstone investors and brokers that are needed. It is good news that companies such as Circassia have listed on the main market, and that new forms of growth equity are emerging, such as Neil Woodford's specialist healthcare funds.

[4] Triadic patents are families of patents issued in Europe, Japan and the US. Source: OECD innovation factbook
[5] UK innovation ecosystem briefing, point 5

5. The NHS seems to work against innovation, from trial bureaucracy to uptake processes

Single centre phase I trials are reasonably easy to conduct in the UK, for instance at the Royal Marsden experimental cancer drug centre. NIHR and NOCRI are to be commended for the turnaround in UK trial performance they have delivered since 2011. 66% now hit NIHR's internal benchmark of less than 70 days from a complete request to first patient trial enrolment[6]. However, multi-centre trials remain a challenge in the NHS, despite that progress. Every Trust must review and agree the local protocol and ethics. Finding eligible patients remains a highly manual process. The lack of uniform molecular testing makes national recruitment to biomarkered trials a challenge. In contrast, systems like the one established in France have uniform national testing explicitly designed to facilitate late stage trials[7]. As a result, UK centres in multi-country trials are still seen as slow to recruit by industry. If we are to support our local CRO industry, and get more patients into late stage trial, we need to do more. It is great that Genomics England is piloting new models for this. Hospital bureaucracy, for instance drug and therapeutic committees, is preventing patients using early access and off label medications, even (as in the Cancer Drugs Fund) when reimbursed centrally. Advanced diagnostics routinely fail to get local access, even when NICE-approved, as care tariffs are updated many years after NICE review, and implementation that would save costs often requires care pathway redesign to achieve that saving. The commissioning reforms have not helped the innovation cause given the confusion they have created.

6. Academic incentives still prioritise "citation chasing" behaviours over "real world" impact

Individual academic incentives are still heavily skewed to citations and impact factors, for instance as the basis of grant renewal or university career progression or academic society recognition. The REF has changed the behaviours of their employers. It will take more time and further refinement of the role of impact in academic career paths for it to really change front line behaviours.

7. UK technology transfer needs to be improved

Increasingly the nature of the UK's life sciences sector is collaborative. Despite inherent challenges in collaborations between academic and industry partners there are many examples of varied and successful UK partnerships that are producing world leading products and technologies.

However, multiple reports and our members' experiences suggest that TTOs are often perceived as a barrier to success. Some argue that the challenge lies in the employment law contract between academics and their universities. Almost all agree that not as much innovation as we want comes out from our world class science base in a timely and investable format. We need TTO processes and incentives that align with those of industry and value longer term benefits over short-to-medium term revenues. It's also crucial to improve the technology transfer user experience, building a culture and framework within academic departments that supports and rewards researchers to collaborate with industry and provides appropriate incentives to do so.

8. Inability to compete for the best commercial biotech talent

Too many exceptional entrepreneurs and scientists leave for the US each year, where the commercial opportunities are greatest and career prospects brightest. If the ambition is to create a Boston sized cluster, with approximately 130 more "investable" management teams in 10 years' time, we need to be attracting the brightest minds, not exporting them.

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[6] Published performance on clinical trials receiving NHS permission in the 12 months to 30/06/2014

[7] Plateformes hospitalières de génétique moléculaire des cancers : faits marquants et synthèse d'activité 2013

9. System fragmentation, complexity and lack of overall impact strategy

The UK's biotech ecosystem is highly fragmented and whilst there is strength in an interdependent funding model, there is little effective coordination of translation. Some examples:

- **The complexity of the funding landscape:** In the UK, Wellcome Trust, NIHR and MRC are each large funders in their own right. There is some formal, high level coordination, e.g. via the Office for the Strategic Coordination of Health Research (OSHCR). However, it doesn't seem to be enough to prevent funding duplication and PIs trading one funder off against another. In the USA , National Institutes of Health (NIH)'s behaviour and strategy drive the basic research agenda, coupled with significant US federal departmental investment. That said, a diverse and interdependent funding model does provide various advantages, including preventing "group-think". But more could be done to drive better coordination of frontline funding.
- **Competing life sciences groups** (One Nucleus, BIA, the Open Bioscience Network (OBN), the British In Vitro Diagnostic Association (BIVDA), the NHSA etc.), vs. Mass Bio
- **Multiple agencies of government**: Innovate UK, the Office for Life Sciences (OLS), regional organisations like MedCity and Scottish Enterprise
- **Many small universities**, all competing for grants, each with their own TTO, each sub-scale globally. As an example, biomedical research funding into London, Cambridge and Oxford averaged £0.47bn per city in 2012. Into the next four cities (Edinburgh, Manchester, Dundee, Newcastle) it averaged £0.09bn. Into Boston and San Fransisco it averaged £1.05bn. Yes, individually each institution has some world class science. The challenge is that it is often taking place in systems that lack the bench-depth to create the flexibility and support systems to power translation.

This lack of focus and overall strategy must be fixed to get the system to work. Translation is too expensive and too difficult to be left to chance.

As one of our experts put it, *"Civil servants seem to believe in trickle down innovation – if you put the money into basic research, health and economic benefits will naturally and spontaneously occur. It just simply isn't true. We need active mechanisms to drive translation. Otherwise the academics will remain focused on Nobel Prizes and ignore impact."*

Hypothesis – 10 themes to making this vision a reality

1. **10x more strategic**. The UK system is fragmented – by geography, funder, sector, and body. Coordination could be improved. There is not yet an innovation strategy specific to life sciences despite its unique innovation needs and economic potential for the UK. There is only a finite pot of government and charity money to pump-prime success in a global race.

   We need a "grand alliance" across this sector that works towards this shared vision. It will need new, more integrated governance covering NHS, the major funders, government, regulators and the private sector. It will need to make the "importance of place" in translation important in its delivery model. Mass Life could an appropriate model for such an alliance and further details of its structure are contained at Appendix 1.

2. **10x more focused on patient benefit**, by focusing on differentiation, unmet need and health economics. The market for a medicine are patients with unmet medical needs. Regulated therapies have to be better than existing technology to get to market. They won't get to patients unless they are affordable. Strategically as a sector we don't focus on this enough. Our academics and funders lack good information on unmet need. We don't have good information on the strengths and gaps in our science base against these needs and global competition. Pharma and the best single disease charities make use of these tools to strategically maximise patient benefit. Tactically, it is hard for UK basic researchers to get clinical and commercial input into early ideas to better test their potential to help patients.

   We need to build behaviours and tools that will help researchers understand the role patient benefit and health economics have in effective innovation, and the tools and systems to get help to researchers with an early idea. Natural owners for this could be the disease charities, spanning as they do from patient need to basic research. They are also natural "neutral parties" to help catalyse new ways of improving translation effectiveness.

3. **10x more growth equity**. An acute issue in the UK is a lack of growth capital. Without that money there is nothing to drive clinical innovation. Without it, UK venture investment is structurally less profitable than US investment and so less venture funding is available. Without it, the UK offers little incentive to attract global talent or get academics excited by innovation. Without it, management teams have no option but to sell early, forgoing local jobs and value. Our benchmarking shows that we will need need billions a year more to build success.

   Multiple paths to this money are needed given the scale of the funding gap: issues that should be considered include making NASDAQ listing easy and tax effective (as Israel does), reforms to AIM (like the US JOBS act), unlocking charity balance sheets for mission-linked investment, unlocking Ultra High Net Worth (UHNW) investment in "super-EIS" schemes for R&D tax credit collecting investments, and unlocking pension fund money (e.g. with actuarial risk selection rule changes to shift assets away from low return bonds).

4. **10x more academics and clinicians willing to try**. Despite progress, academics and clinicians here are still less likely to initiate translation than in the US. Translation offers little personal incentive. Founders in this system rarely see a return at exit. Translation is hard to combine with an academic or NHS career – there is no revolving door to industry and academia, and efforts focused on translation don't generate papers or benefit patients now.

   We must continue to improve academic and university incentives (such as REF) to change innovation behaviours. Belgian-based VIB's PI and institutional scorecards could be an appropriate refinement.

5. **10x more willing to fail.** Early failure is cheaper failure, and fast to fail systems are cheaper overall at delivering innovation. Too many weak assets are being kept alive in this system, both in academia and the private sector. We need more ruthlessness from concept testing to phase II to make better use of its limited money and talent.

   In turn, that means a culture that embraces "good" failure across the sector. It means better design and funding for the killer early experiments / trials so their results are definitive. It means keeping management in the system who have "failed well" – scientifically and fast. It means tackling tough subjects such as clinical trial publication bias against negative results.

6. **10x better knowledge transfer**. Some of our TTOs inhibit translation, many of our academics lack commercial skills, and we don't have enough medium sized companies who can invest back in universities to help correct this. The BMC has been a great source of funds, but doesn't fix this capability issue. These capabilities are broadly disease area specific – the market dynamics, translation process, people and industry partners are unique to each disease, and so the solutions will need to be tailored by disease.

   We have a few mechanisms to drive disease specific knowledge transfer - the Cell Therapy Catapult and CRUK new drug office as examples. We need many others. These could be reached via radical TTO reform and specialisation, or in partnership with disease specific programmes, such as the new dementia centres or the metabolic disorders initiatives. Disease specific charities like Fight for Sight could have a key role in making this happen, by joining up the system from lab to patient (just as CRUK does today in cancer).

7. **10x better concept testing**. Concept development and testing is weak, both in academia and our smallest SMEs. Patents can be broadened at national stage, but need experimental evidence to support this, for which there are few sources of timely funds. "Killer experiments", which can make the difference between private investments or not, need to be done to the standards and designs required by industry and to GLP. Accessing the expertise that can advise on these issues is hard as it is so dispersed.

   We need to drive a revolution in concept development and testing, with disease specific expertise networks and faster, local access to exemplification funds in universities. The expert networks built up by the translational awards and augmented by willing industry partners could provide a backbone for this, with appropriate confidentiality controls. Topping up now empty challenge funds could transform early concept development funding.

8. **10x more NHS engagement**. The NHS should be a big asset for the UK in biomedicine, be it as a trial environment to get clinical proof of concept, creating new clinical data business models that bring wealth to the UK via big data, or trial innovations that can bring drugs to market at lower cost. Biomedical innovation also has real potential to cut the cost of care – for instance modern diagnostics / theranostics that result in more effective targeting of drugs.

   However, the NHS appears today to work against innovation at many levels. Clinical trial bureaucracy / risk aversion and the fragmentation of the Trust landscape has led the UK to fall from 17% of global trials to low single digit today. Commissioning processes are generally unfavourable to innovation. For instance, modern diagnostics are often not reimbursed, even when (like Oncotype Dx) they have NICE approval.

   Even where innovation is centrally reimbursed (e.g. via Cancer Drugs Fund), the uptake of new medicines in off-label or near-label applications is hindered by substantial variation in Trust and NHS region governance. For instance, some drug and therapy committees prevent doctors using compassionate or off-label drugs. The care quality consequences of this variability are not effectively managed or challenged – we don't have effective disease specific outcome tracking data to make that possible, unlike say Sweden.

   We need to find ways to make the NHS better able to support and use innovation to the benefit of both UK health and the broader innovation agenda. Some of this will require governance and policy changes (e.g. to make early access happen on the ground). Some of this will require new systems and processes (e.g. to make the NHS effective in running multi-centre biomarkered trials). Some of this will require new incentives, both to Trusts and between the NHS and private sector innovators – for instance, effective risk shares.

9. **10x more biotech management talent**. In drug development alone, we need at least 130 extra clinical stage management teams. We will need yet more talent in other health innovation and support service sectors. That talent needs to be more ambitious, multi-skilled and to have the right leadership behaviours to drive growth and global success.

   An integrated plan for how to source and develop this talent is essential, and will need to tackle such sensitive topics as skilled immigration, pay and leadership behaviours. We also need to "recycle" commercial talent more effectively.

10. **10x more celebration of success**. There is emerging success and amazing patient stories across this sector, but they remain under-sung. Too often we are excessively self-critical, perhaps conscious of the dangers of hype. Too few of us have the facts to hand to sell the positive changes and momentum in our sector to our colleagues, and the broader benefits to patients and society that we create.

    To mobilise for change, we need to celebrate our success more, champion the sector internationally and create the positive momentum to make this vision reality. This needs to happen both at a level the public and health system can engage (such as patient impact stories) as well as investors (great return stories). As the sector matures, it should also celebrate success in terms of R&D inputs vs tax-take, as Mass Life does.

This vision has been developed by the BIA in discussion with its Board and in dialogue with broader experts. We publish this document to start a debate, rather than present this as a definitive set of conclusions. We would very much welcome your feedback.

Please contacts us on 020 7630 2180 or info@bioindustry.org

Appendix 1: Case study – Mass Life, guardian of the Boston Cluster[8]

Summary

Mass Life is a cross-sector Boston organisation administering a $1bn 10 year fund started in 2007. It invests in a targeted and effective way to maintain Boston's pre-eminence in medical biotechnology. Its investments span translational awards, skills development, job creation and infrastructure. It carries out social research on the cluster to identify unmet need in the system as well as to measure its effectiveness in terms of creating jobs, leveraging its funds and providing a return to tax payers. It is seen in the state as being highly effective in terms of leading the improvement of the cluster in a cross-disciplinary way, and providing great value for money to the taxpayer. Key to its success has been private sector management and a "venture philanthropy" mindset under a cross-sector board.

Vision & Mission

The Massachusetts Life Sciences Initiative (colloquially Mass Life) is a 10-year, $1bn investment to enhance the state's leadership in the life sciences, and to strengthen the life sciences as the engine for sustained growth in the Commonwealth. It was a specific investment to maintain and grow the Boston cluster's global position in the face of intense competition, begun in 2008. In its own words, "Innovation is a process, and that process is enabled or hindered at critical points by the presence or absence of certain key success factors. [We have] been assessing these critical success factors in Massachusetts and … make targeted investments that help close the gaps."

Initiation

Harvard business school Professor Michael Porter and the presidents of MIT and Harvard convened a summit of university leaders, educators and business representatives in 2003 to discuss the super-cluster, its importance to the state and how to improve its global competitiveness. A $125k investment by The Boston Foundation created the Massachusetts Life Science Collaborative with an organising committee from across the major universities and hospitals, life sciences companies and venture capital firms. Its purpose was to design the fundable long term plan. Governor Patrick announced the $1bn initiative at the 2007 BIO international convention and it launched in 2008.

Governance

Board: Seven very senior representatives from state government, academia and private sector. Examples include Edward J. Benz, M.D., President and CEO, Dana-Farber Cancer Institute, Josh Boger, Ph.D. Founder & CEO (retired), Vertex Pharmaceuticals

Management: almost completely private sector. CEO is founder of a life sciences consulting boutique and is supported by a senior scientific and venture advisory "board/expert" network for the detailed grant review.

The broad philosophy is to apply private sector thinking and behaviours in a venture philanthropic way to drive growth in the cluster and health outcomes globally. Independent reviews of its success point to the following factors: i) quality of its management ii) its intellectual discipline, both in its strategic approach and in its grant giving iii) its speed of decision making / service orientation iv) its focus on measurable impact, often measured using innovative social science techniques and v) its commitment to new forms of collaboration such as pre-competitive consortia.

[8] Sources used are previous expert interviews, Mass Life's Fiscal Year (FY) 2013 Annual Report, Life Sciences Innovation as a Catalyst for Economic Development: The Role of the Massachusetts Life Sciences Center (North Eastern University 2013) and www.masslifesciences.com

Granting Programmes (cumulative spend 2008-12 $m in brackets)

- Capital Projects Fund to provide capital for equipment and supplies for high schools in Gateway Cities, vocational/technical schools, and community colleges; and for capital projects at academic/research institutions, business incubators, and other not-for-profit organizations. In the main this builds business incubators and disease focused translational labs. ($187m)
- Life Sciences Tax Incentive Program to offer a combination of 10 competitively awarded tax incentives available to companies that meet specified hiring goals. ($56.6m)
- Cooperative Research Grants to support industry-sponsored research at universities in order to facilitate scientific discoveries that lead to medical applications. These grants match industry contributions dollar for dollar. As an example, the Massachusetts Neuroscience Consortium, a pre-competitive consortium of seven pharma companies and four research institutes in Alzheimer's, MS, Parkinson's and neuropathic pain. ($23m with new investigator grants)
- New Investigator Grants to spur innovative research and advance the careers of new investigators working on cutting-edge research at academic research centres in Massachusetts.
- Life Sciences Accelerator Loan Program & Small Business Matching Grant (SBMG): the accelerator makes loans available to early-stage companies and helps leverage additional sources of capital. SBMG program to provide matching support to firms on the verge of commercialising new technologies developed with Phase II or Post-Phase II federal Small Business Innovation Research (SBIR) awards or federal Small Business Technology Transfer (STTR) grants. ($23m)
- Training the Next Generation of Life Sciences Experts, with intern programmes, veteran programmes and new entrepreneurship models. As examples, the intern programme provides full funds for young interns working 12 weeks at start-up and smaller Massachusetts life sciences companies. 30% go on to get jobs with those firms ($7m). One specific award pays for entrepreneurs to shadow clinicians to identify unmet need in hospital wards in the hope of kicking off new medical device innovations (Ignite shadowing programme).

The programmes are competitively tendered, often in focused areas where the cluster needs investment (for instance a current big data grant to diagnose the potential for big data and the needs of the system to develop that sector). Overall for every $ invested, they have attracted $2.6 of matched funding to bring in a total of $1.45bn new funding to Boston.

Directly funded programmes

- Attracting companies to Massachusetts: active marketing of Boston as a destination. Now, all top 10 pharma have R&D or manufacturing sites in the state.
- Impact evaluation: for instance commissioning independent research on the economic impact of the initiative and the cluster, as well as new economic research on why high tech clusters work.
- Senior networking and convening: using its status and board, it convenes specific workshops on key issues facing the cluster with top experts, and catalyses the best ideas that come out of those events into policy and practical action.

Measurement and accountability

Mass Life places great emphasis on measurement and accountability. As well as conventional financial controls, it creates custom measurement and review processes for most programmes. It places great emphasis on partner satisfaction and matched funding secured on most of its individual programmes. It also commissions innovative socio-economic research on its overall impact, measuring for instance direct job creation in the cluster, return on tax payer dollars invested in terms of tax benefit over five years and commissioning new research on why pharma co-locate to high tech clusters.

Appendix 2: UK vs Massachusetts and California benchmarking methodology

All metrics benchmarked are normalised to UK R&D input of £3.3bn p.a. across the MRC, NIHR, Innovate UK, Biotechnology and Biological Sciences Research Council (BBSRC) and Association of Medical Research Charities (AMRC) vs £4.7bn averaged in MA & CA and the relevant metric average across Massachusetts (MA) & California (CA). i.e. one should expect the UK to perform at roughly ¾ the level of the MA & CA average; exchange rate applied is £1:$1.7.

The Science:

We attempted to be as complete as possible on the funding environment. UK research input includes all AMRC members, MRC, BBSRC and NIHR funding but not EU funds (which are hard to breakdown by country). Engineering funds, such as Engineering and Physical Sciences Research Council (EPSRC) funds have been excluded for similar reasons. US data is likewise all governmental and not-for-profit research input[9].

The Money:

Venture money was estimated using E&Y Beyond Borders triangulated with PWC MoneyTree and British Venture Capital Association (BVCA) data. Dealogic was used for listed IPO funds raised and secondaries. Values shown are before bank fees and expenses. Secondary deal value data was available for only 70% of deals by number in MA and CA – number shown scaled to 100%.

The Clinic:

As a proxy for health impact / ability of each system to get innovation to clinic we chose two metrics:

- number of private biotechs in clinical trial (from EvaluatePharma)
- number of of listed pre-commercial biotechs with < $20m sales (from Capital IQ)

This sample was chosen to ensure the most robust metric possible could be created given the potential for bias and inaccuracy in predicting product pipelines. Entry into clinical trials and company listings are public regulator notifiable events, and so these criteria eliminate this potential bias.

While this sample is highly comparable across the systems, it is not complete. For instance, private device companies in clinical trial are not included. The other example would be pharma buying academic-developed pre-clinical assets and taking them into trial. To include pharma would require detailed pipeline analysis of where they had sourced their assets, for which there was not time. The sales criteria of $20m are designed to exclude large and established mid-cap pharma while allowing in "service & early development" companies like Horizon Discovery.

The Wealth

The wealth analysis is based on an analysis of sector specific UK Standard Industry Classification codes (SIC codes) and USA North American Industry Classification System codes (NIACS codes) and jobs and salary surveys from their respective statistical offices. Five UK SIC codes with exact matches to 11 US NIACS codes were used, specifically:

- 211 Manufacture of basic pharmaceutical products (to 325411, 325413, 325414)
- 212 Manufacture of pharmaceutical preparations (to 325412)
- 266 Manufacture of irradiation; electromedical equipment (to 334510, 334517)
- 325 Manufacture of medical and dental instruments and supplies (to 339112-115)
- 721.1 Research and experimental development on biotechnology (to 541711)

[9] Author location is for any author in either UK or the relevant US state. Sources: UK research funder websites and annual reports; researchamerica.org; Web of Science

These codes represent a sub-set of the biotechnology cluster. North Eastern University has estimated the Boston cluster potential in detail over a broader range of sectors[10], for instance including labs, diagnostics and drug distribution. Exact matches for these codes could not be made to the UK SIC codes, and so would not give an "apples to apples" comparison and were excluded. Employment in the 11 NIACS codes used represents 52% of the employment North Eastern and Mass Bio estimate in Boston Life Sciences sector, i.e. the SIC codes used for this benchmarking are about half the sector. As a result, the wealth gap based on this sample have been ranged x2, both in terms of potential extra employment and salaries.

The surveys used were ONS 2012 Business register and employment survey, US Bureau of Labour Statistics 2012, accessed online at a state level. Salary data is fully loaded (i.e. including employer taxes and pensions).

The results do not include any economic halo effect (the impact of wealth creation in one sector on other sectors, effectively "trickle across" as the employed in this sector buy other general products and services both for their private and business use). Typically, large economic development investments such as new airports estimate these halo effects at three to four times the direct effect.

[10] Life Sciences Innovation as a Catalyst for Economic Development: The Role of the Massachusetts Life Sciences Center, The Kitty and Michael Dukakis Center for Urban and Regional Policy at Northeastern University

Glossary of Terms

AIM	London Stock Exchange market for smaller, growing companies
AMRC	Association of Medical Research Charities
BBSRC	Biotechnology and Biological Sciences Research Council
BD	Business Development
BIA	UK BioIndustry Association
BIVDA	British In Vitro Diagnostics Association
BMC	Biomedical Catalyst
CEO	Chief Executive Officer
CMO	Contract Manufacturing Organisation
CRO	Clinical Research Organisation
CRUK	Cancer Research UK
EIS	Enterprise Investment Scheme
EPSRC	Engineering and Physical Sciences Research Council
GDP	Gross Domestic Product
GLP	Good Laboratory Practice
GMP	Good Manufacturing Practices
Halo effect	The impact of wealth creation in one sector on other sectors, effectively "trickle across" as the employed in this sector buy other general products and services both for their private and business use
HTA	Health Technology Assessment
IP	Intellectual Property
IPO	Initial Public Offering
MRC	Medical Research Council
NASDAQ	The name of an American stock exchange
NHS	National Health Service
NIACS codes	North American Industry Classification System codes
NIH	National Institutes of Health
NHSA	Northern Health Science Alliance
NICE	National Institute for Health and Care Excellence
NIHR	National Institute for Health Research
NOCRI	The NIHR Office for Clinical Research Infrastructure
OBN	Open Bioscience Network
OLS	Office for Life Sciences
OSHCR	Office for the Strategic Coordination of Health Research
PI	Principal Investigator
R&D	Research and Development
REF	Research Excellence Framework
SEIS	Seed Enterprise Investment Scheme
SIC codes	UK Standard Industry Classification codes
SME	Small and Medium Size Enterprise
TMT	Technology, Media and Telecoms
TTO	Technology Transfer Office
UHNW	Ultra High Net Worth
VC	Venture Capital
VIB	Vlaams Instituut voor Biotechnologie, a life sciences research institute based in Belgium

UK BioIndustry Association

Established over 25 years ago at the infancy of biotechnology, the BioIndustry Association (BIA) is the trade association for innovative enterprises involved in UK bioscience. Members include emerging and more established bioscience companies; pharmaceutical companies; academic, research and philanthropic organisations; and service providers to the bioscience sector. The BIA represents the interests of its members to a broad section of stakeholders, from government and regulators to patient groups and the media. Our goal is to secure the UK's position as a global hub and as the best location for innovative research and commercialisation, enabling our world-leading research base to deliver healthcare solutions that can truly make a difference to people's lives.

We are at the forefront of UK bioscience, connecting individuals and organisations, helping to shape the future of the UK sector

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