



Department for
Business, Energy
& Industrial Strategy

Knowledge Quarter Science and Innovation Audit

A Science and Innovation Audit Report
sponsored by the Department for Business,
Energy and Industrial Strategy

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Forewords

Professor Michael Porter popularised the idea in his hugely influential book *The Competitive Advantage of Nations* back in 1990, and policymakers have been trying to build on it ever since. Porter showed how competitive clusters of enterprises can drive innovation, stimulate new business growth and increase the productivity of economic actors in the area. But as many politicians have discovered, such clusters can't be developed artificially. Instead, they tend to be an accident of history – a rare mixture of research-based excellence, entrepreneurial flair and financial capital, all with a strong cultural underpinning. The Knowledge Quarter, stretched around King's Cross in London, has the capacity to be the just the kind of competitive cluster that Porter described. Centred on great research and cultural institutions, it is turning into a magnet for knowledge-intensive industries from around the world. This Science and Innovation Audit shows the impact that is already being felt on the economy of the area. And it suggests that the Knowledge Quarter could develop into an asset of national and global importance as the UK seeks to reposition itself in the world. The British Museum has been in the neighbourhood for a very long time, and will play its part in turning this part of town into a hub of innovation, new ideas, and talent.

Sir Richard Lambert – Chairman of the British Museum

The Knowledge Quarter is a hub of some of the most exciting innovation and enterprise in the United Kingdom. I am therefore delighted to have been invited to provide a foreword to this Science and Innovation Audit, which reviews some of the most exciting growth areas for the Quarter and demonstrates the benefits of location and connection. Next year, we will move to our new office in this vibrant Quarter. At McKinsey, we understand that location matters and are committed to the core dimensions of place: people, capabilities, and assets. Bright ideas and promising collaborations often come from interactions between companies or institutions, united by a shared location, or even a common coffee shop. Accordingly, when McKinsey was looking for a new home in London, we were appropriately rigorous in finding a location where we could attract and retain top global talent, stay closely connected to our clients, and tap into local expertise and knowledge. The Knowledge Quarter exceeded all those requirements, bringing together as it does world-leading centres of Life Sciences such as The Francis Crick Institute, companies on the cutting edge of the data and analytics revolution, and cultural icons such as the British Museum and the British Library.

This Audit report, overseen by a prestigious Steering Group, represents an important step in showcasing what the Knowledge Quarter has to offer its local participants, as well as the regional and global economy. We are proud to become part of this exciting area's journey and hope you enjoy reading about how it intends to continue to go from strength to strength in driving economic growth through attracting top talent, innovation, and connection.

Vivian Hunt - Managing Partner, McKinsey & Company, UK & Ireland

1. Introduction

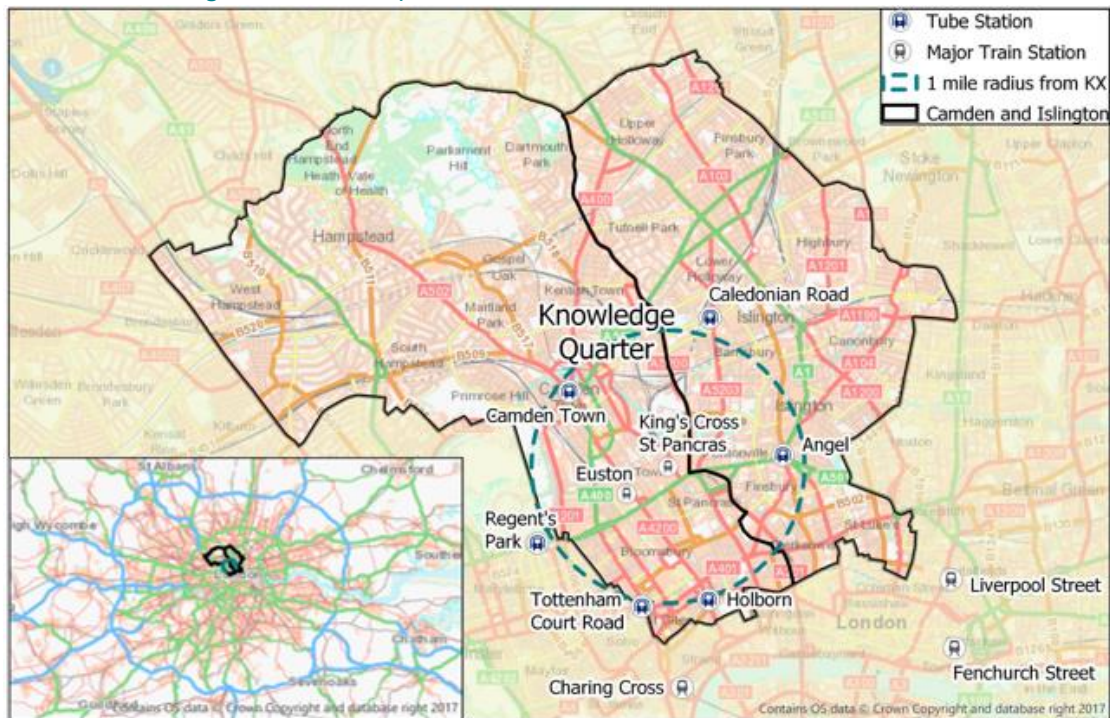
- 1.1 This document presents the **Knowledge Quarter's¹ Science and Innovation Audit** (KQ SIA).
- 1.2 It has been developed by a consortium of partners² with support from SQW. Science and Innovation Audits (SIAs) are part of a new approach to regional economic development which focuses on analysing regional strengths and identifying mechanisms for realising potential. SIAs are sponsored by the Department for Business, Energy and Industrial Strategy (BEIS) and the Government's commitment to them was first announced in Autumn 2015. They feature strongly within the Industrial Strategy White Paper which was published by Government in Autumn 2017.
- 1.3 The KQ SIA examines the principal research strengths and innovation capabilities of businesses and scientific and cultural organisations in London's Knowledge Quarter – the area of Camden and Islington within a radius of about a mile from King's Cross and St Pancras stations³. It also explores their current and prospective partnerships within and beyond the immediate geographical area.
- 1.4 **Our vision is for the whole of the UK to benefit from the world-class expertise, facilities, collections and connectivity that characterise the Knowledge Quarter. By mobilising these assets, we plan to accelerate the pace of discovery, science and innovation at a national level, drive economic growth and help implement the new Industrial Strategy.**
- 1.5 The Audit examines how this vision can be delivered through five 'smart specialisms' (existing or emerging strengths) which are grouped into **three Themes**:
- **Theme 1: Life Sciences** – focusing especially *emerging infectious diseases*, including antimicrobial resistance (AMR); *musculoskeletal pathology associated with ageing*; and *dementias*
 - **Theme 2: Cultural, scientific and heritage collections** – focusing on *digital archiving, curation and publishing*; and
 - **Theme 3: Data Science** – focusing on *machine learning and artificial intelligence (AI)*.
- 1.6 These were chosen because of their **global significance in terms of both the depth of science/knowledge within KQ and their commercial impact and potential.**

¹ Note that the Knowledge Quarter is also the name given to a consortium of partner organisations concerned with advancing and disseminating knowledge. It is doing much to animate the knowledge exchange and innovation within the area. However, throughout this Science and Innovation Audit, the term "Knowledge Quarter (KQ)" is used to refer to the area, not the partnership. Where we refer to the partnership, we describe it as "Knowledge Quarter Partnership (KQP)"

² This included British Library; Royal Veterinary College; KQ Partnership; Camden Council; UCL; City, University of London; Birkbeck, University of London; and the London School of Hygiene and Tropical Medicine. See Annex B for more information

³ For statistical purposes, the Knowledge Quarter is proxied by two London boroughs: Camden and Islington. In practice, the focus of the KQ is the southern parts of the two boroughs within about a mile of King's Cross railway station

Figure 1-1: Map of Camden and Islington showing the Knowledge Quarter (the area within a one-mile radius of King's Cross station)



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Framing the Knowledge Quarter Science and Innovation Audit

- 1.7 The historical evolution of the Knowledge Quarter is long and intricate. It is bound up with key moments in the development of science and knowledge of global significance (see Table 1-1).

Table 1-1: Historical evolution of the Knowledge Quarter – both as a focus for science and knowledge, and as a place

	Key institutional developments of relevance to the SIA	Wider developments within the geography of KQ
1700 – 1799	Founding Hospital, British Museum and Royal Veterinary College (RVC) founded	Euston Road completed
1800 – 1899	- University College London; Northampton Institute (now City, University of London); Working Men's College; and Slade School of Fine Art founded - Great Ormond Street Hospital; and National Hospital for Neurology and Neurosurgery set up	- Regent's Canal completed - King's Cross station and St Pancras Station opened - Great Northern Hotel opened
1900 – 1949	"Old Bloomsbury" group begins to meet - British Medical Association moves to BMA House - Charles Dickens Museum opens - University of London established and subsequently moves to Senate House - London School of Hygiene and Tropical Medicine moves to Bloomsbury, as does the School of Oriental and African Studies (SOAS) - Wellcome Building opens	Completion of Camden Council Town Hall
1950 – 1999	- Birkbeck moves to Malet Street - Institute of Education moves to Brutalist building on Bedford Way - London Metropolitan Archives moves to Clerkenwell - Bloomsbury Publishing founded - British Library building opens	- Development begins on Regent's Place - Euston Station redeveloped

	Key institutional developments of relevance to the SIA	Wider developments within the geography of KQ
2000 – 2014	• London Bioscience Innovation Centre (LBIC) opens • New University College Hospital building opens • Wellcome Collection opens • Central Saint Martins opens near King's Cross • Benevolent AI is founded and incubated at LBIC • Knowledge Quarter is founded	• St Pancras International terminus opens; and Eurostar opens a new terminal • Area around King's Cross station is comprehensively redeveloped • King's Place opens
2015 – 2017	• Alan Turing Institute is founded • Francis Crick Institute is founded • Google moves Engineering division to King's Cross	
From 2018...	• Aga Khan University will open new campus • British Library extension to be completed	• Crossrail due to open • HS2 will open • Euston Station area will be redeveloped

1.8 As a result of these different “rounds of investment” – both institutional and more directly place-based – the Knowledge Quarter is now simultaneously:

- **a major focus for the UK's knowledge-based assets**

These include – but are not restricted to – its scientific and research capabilities (some of which are the focus for this Science and Innovation Audit). Major organisations, institutions and businesses within KQ include, for example, **British Library, DeepMind, The Francis Crick Institute, Alan Turing Institute, Wellcome Trust and University College London (UCL)**, amongst many others.

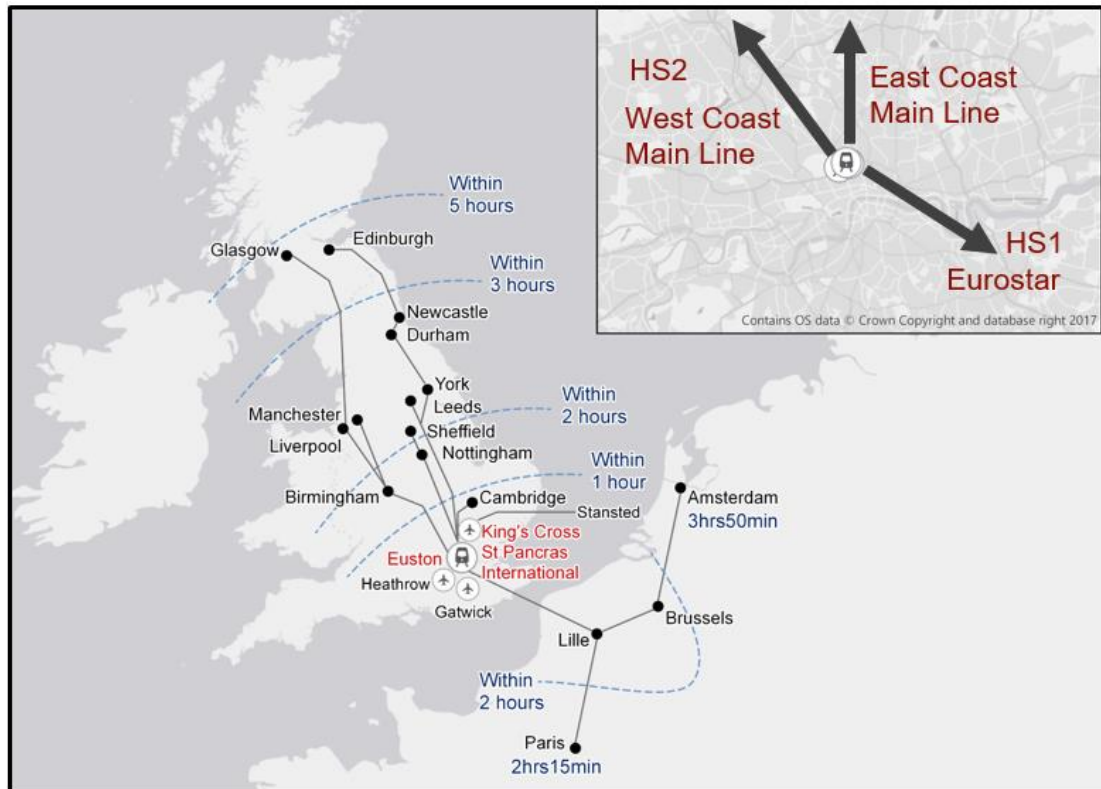
- **part of a dynamic and vibrant “world city”**

London has seen sustained growth and investment, particularly over the last two decades. This has included the physical transformation of the area around King's Cross/St Pancras railway stations (i.e. the heart of the area we are defining as the KQ). However, London and KQ also face both social and physical challenges as the corollary of growth.

- **the hub of the national rail network**

KQ benefits from the East Coast Mainline (King's Cross) and the West Coast Mainline (Euston) railways, and from HS1/Eurostar (St Pancras). It has the prospect of HS2 (Euston). All of this means that **the KQ is very well connected to most of the UK's major cities and to continental Europe.**

Figure 1-2: Map showing national and international connections to the Knowledge Quarter



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Our Hypotheses

- 1.9 As we demonstrate through this SIA, the KQ has an abundance of leading-edge anchor institutions and companies, with some links to start-ups, business incubators and accelerators. These are necessary (although not sufficient) to deliver the vision we have set out above.
- 1.10 Much more difficult to both identify and codify is the strength of “weak ties”, the mechanisms through which these are created, and the competitive advantages that follow (including in relation to processes of open innovation). This has led to the definition of the **first hypothesis** that we have sought to test through the Audit: *that close proximity in an urban setting facilitates open innovation between knowledge-based organisations (Hypothesis 1)*.
- 1.11 Proximity in this context is not enough – and through the SIA, we have found examples which illustrate clearly why this is the case. It is for this reason that the actual or potential role of place-based network brokers in galvanising “weak ties” has been another consideration. Our **second hypothesis** has been *that place-based ‘network brokers’ have an important role to play in catalysing relationships (Hypothesis 2)*.
- 1.12 The scale of investment and depth of the KQ’s asset base are sufficient to afford the area real responsibilities. Two questions – with significant policy implications – follow:
 - whether the KQ is harnessing its knowledge-based assets and locational advantages effectively and generating commensurate economic benefits for the UK more generally (including, for example, through jobs that may be created elsewhere)

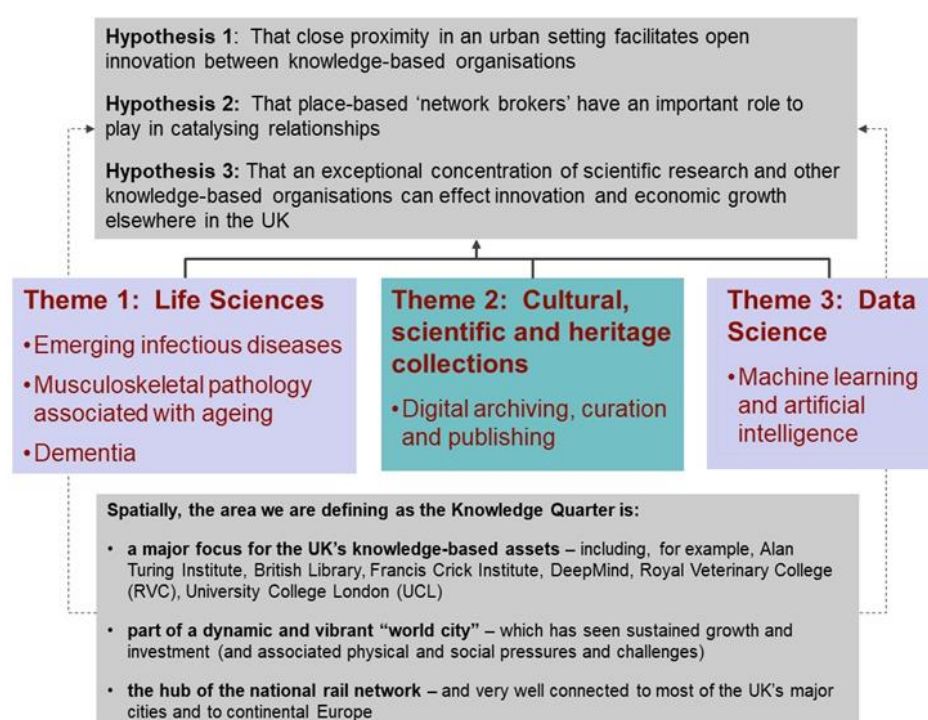
- whether the processes through which knowledge assets are harnessed and exploited are benefitting the wider population of Camden and Islington as much as they could.

1.13 Given the purposes of an SIA, our immediate focus has been mainly on the first of these two issues, although we have had regard to both⁴. The **third hypothesis** that we have sought to test through the Audit has been *that an exceptional concentration of scientific research and other knowledge-based organisations can effect innovation and growth elsewhere in the UK (Hypothesis 3)*.

Structure of the KQ SIA

1.14 Taking our Hypotheses and Themes together, the structure of our SIA is summarised in Figure 1-3.

Figure 1-3: Overall structure of the Knowledge Quarter Science and Innovation Audit



1.15 The chapters that follow explore the different elements of Figure 1-3. They adhere to the required structure of a Science and Innovation Audit (as defined by BEIS), but we have added two additional chapters in order to capture more fully the essence of the Knowledge Quarter and the processes outlined above. The report is structured as follows:

- building on these introductory comments, **Chapter 2** considers – in summary terms – the nature of the Knowledge Quarter as a “place”; this analysis is important in understanding the spatial underpinnings of the Knowledge Quarter's assets and the opportunities and constraints (particularly in relation to innovation and commercialisation) linked to them

⁴ The local dimensions – social and economic – of growth linked to the KQ were considered in some detail through our consideration of place and are reported briefly in Chapter 2

- **Chapter 3** describes in more detail the overall strength of the Knowledge Quarter's scientific and knowledge-based assets
 - **Chapters 4, 5 and 6** consider each of the three **Themes** in some depth
 - **Chapter 7** then attempts to look across the Themes to understand the nature and extent of links between them in order, essentially, to test the three hypotheses
 - finally, **Chapter 8** draws together the earlier analyses to focus on opportunities that might be harnessed and gaps that might be addressed such that the impacts arising from the Knowledge Quarter might be enhanced.
- 1.16 There are three supporting annexes. Annex A provides high level outline business cases for the interventions that have been identified through this SIA. Annex B explains how the Audit was completed and the sources of evidence on which it relied. Annex C provides a list of contributing organisations.
- 1.17 In addition, there is a supporting volume of appendices. This includes the original SIA expression of interest, as well as further evidence on international comparators, market trends and the availability of business space in the KQ and its surrounding area. This evidence has helped to inform the development of the SIA.



2. Understanding the place: looking inside the Knowledge Quarter

Chapter Summary:

The Knowledge Quarter is an area within central London that needs to be understood both as a distinct “place” and in terms of substantial “flows” (of people, ideas, investment and knowledge), locally, nationally and internationally. It has seen rapid and sustained growth over recent years, but this is creating its own pressures and challenges.

Facilitated by the national rail infrastructure, its employers draw on a very extensive labour market, although its infrastructure is under a good deal of pressure as a result. Employment sites and premises are expensive and in short supply, and they are also being lost to housing through Permitted Development Rights. There is much evidence to suggest significant under provision of sites and premises within a few minutes’ walk of the principal scientific and knowledge-based institutions.

Although Camden and Islington perform well in terms of the overall skills profile of local residents, both boroughs are very diverse in socio-economic terms. Areas of significant poverty and disadvantage exist alongside areas of affluence, and these tend to be conflated in aggregate statistics. There are also substantial housing market pressures.

- 2.1 Consistent with the purposes of an SIA, much of the rest of this report is concerned with the KQ’s scientific and knowledge-based assets, and its innovation capabilities. To contextualise this narrative, the paragraphs that follow provide a brief description of the KQ area.

Place-making across the Knowledge Quarter

- 2.2 The Knowledge Quarter needs to be recognised as a distinctive “place” – albeit one that has seen substantial change over recent years. The area around King’s Cross station has been transformed over the last decade, and a similar process of transformation is likely to be seen in the vicinity of Euston over the next 10 years. This process is ongoing and it is an essential underpinning of the area’s innovative potential. The case study below relates to a major planned project – the **British Library Extension**, which will extend the redevelopment of the area around King’s Cross/ St Pancras westwards towards the major planned regeneration of Euston. It is centrally important to the area’s scientific strengths and innovation assets, and it relates to all three of the SIA Themes. It is also concerned, fundamentally, with the creation of “place” as an asset in its own right.

Box 2-1: British Library Extension Project

The British Library Extension Project is a major scheme to develop a 2.8 acre site which is situated between the British Library and The Francis Crick Institute. This project encapsulates the strengths and potential of the Knowledge Quarter as a globally significant innovation district.

For the British Library, the Extension Project must deliver a space that will enable the delivery of its Living Knowledge Strategy. It must also improve public access while being financially viable. Beyond this, the initial brief included:

1. **space for the expansion of the British Library** to enable it to evolve as one of the world’s leading knowledge hubs for the 21st century, with a design ethos to allow greater openness for the public. This would include new exhibition space to enable greater visibility of the Library’s collections including digital, sound and vision; new facilities for learning programmes and the local community; and an enhanced offering for Business and IP Centre (BIPC) users. The Library’s internal business case placed as great an emphasis on the public benefits that would arise as on the commercial benefits.

2. **space to create a permanent headquarters for the Alan Turing Institute** – a key institution in respect of data science and artificial intelligence within the Knowledge Quarter.
3. **extensive, flexible commercial accommodation for companies, institutions and research organisations, especially in life sciences, data science and artificial intelligence**, ensuring future development of this site in line with the “Knowledge Quarter ethos”.

The site’s main development partner is Mitsui Fudosan, in partnership with Stanhope and architects Rogers Stirk Harbour + Partners.

At first, Mitsui and partners had a concern that commercial space would be ‘out of place’. Further conversations led to the realisation that the provision of such space in line with the Knowledge Quarter aims and ethos is both desirable and likely to maximise the benefits. As a Japanese-headquartered company, Mitsui also had concerns regarding Brexit’s impact on the UK economy and on London specifically. However, visitors from Mitsui’s head office in Japan see the Knowledge Quarter area as ‘exceptional’: it is at the centre of gravity of the ‘Golden Triangle’, and should be robust enough to weather any storm that Brexit (or other economic woes) can produce.

In the view of Mitsui, the KQ is the best-connected part of London, with fast access to Cambridge, the North (HS2 from 2025/6), and mainland Europe (Eurostar). For potential tenants, especially in life sciences, it is this factor AND proximity to The Francis Crick Institute (ideally less than a 10-minute walk) that is most significant. This is particularly the case for non-British clients. Ease of connection is “very potent” when overseas clients come to view the site.

The British Library Extension will be built with place-shaping firmly in mind. The plans include a new northern entrance, close to The Francis Crick Institute and the main St Pancras Station concourse. New spaces will be designed to engage more deeply with the communities of Camden and Somers Town. The aim is also to create a through-route from the revamped Euston/HS2 terminus to St Pancras and King’s Cross, ensuring high permeability of the site.

The current concept has been developed over some 18 months, testing ideas to see what potential synergies might arise from bringing together different types of tenants to create a working ecosystem. Over this period, the need for the tenants to be able to connect easily and thereafter to collaborate with one another has come to the fore: the aim now is to create an “*amazing meeting place*”. The engagement with the London Borough of Camden on ‘Knowledge Quarter’ uses will become key to balancing the strategic planning objectives for the site.

The Alan Turing Institute is a key part of the BL Extension project. The Turing Institute was created by five founding universities and the EPSRC as the national institute for data science in 2015. Since then, a further eight universities have announced that they will join; other partners include Lloyd’s Register Foundation, Intel, GCHQ and HSBC. The British Library has developed a joint research programme with the Turing Institute around digital challenges related to its collections. In the context of discussions around the Extension project, the Turing Institute is delivering a major health programme in data-driven innovation in AI and statistical science; this aims to accelerate the scientific understanding of human disease, patient care and health applications, including working with The Francis Crick Institute (nearby).

The belief therefore is that this major new project should be a further catalyst and focus of the development of the science, knowledge and innovation ecosystem that defines the core of the Knowledge Quarter.

The building itself is likely to be completed in 2023.

Source: Based on discussions with Mitsui and British Library as part of the SIA

Flows across the Knowledge Quarter

- 2.3 At the same time, it is impossible to understand the KQ without some acknowledgement of the scale and density of “flows” – within London, across the Greater South East, nationally and internationally. It is in part because of these “flows” that KQ has attracted significant global businesses (see Box 2-2).

Box 2-2: Case study of Google: Choosing King’s Cross as the location for the UK campus

Google announced in June 2017 plans to build a new Google Campus at King’s Cross, accommodating up to 7,000 staff across three buildings including a flagship 1m sq ft building designed by Bjarke Ingels Group and Thomas Heatherwick Studios. This builds on the existing presence at 6 Pancras Square, which hosts business and engineering teams including DeepMind. The Knowledge Quarter was referenced along with the growing knowledge economy as being supported through this vision.

The Real Estate Workspace Services group of Google is responsible for delivering the right buildings and facilities for the business. This covers all aspects from finding the right location, to the right architecture and design that positions the building and the brand in a way that works for staff, visitors and the neighbourhood, as well as facilitating the 'intrapreneurship' that drives innovation and ideas. King's Cross presented Google with the right site at the right time, but most importantly it met two criteria in abundance; connectivity and quality of place. Both are essential in the recruitment and retention of talent.

King's Cross is a hub for London Underground, national and suburban rail connections. Some eight million people live within one hour and 14m people within 90 minutes – considered reasonable commuting times – but importantly, the majority of these journeys are direct or with little friction through changes and convoluted routes. Secondly, King's Cross is a crucial 'pivot' point linking other clusters such as the Golden Triangle, Here East and Central London. Excellent international links via Eurostar or through the connected airports (Gatwick and Luton directly, and Heathrow and City Airport are within the one-hour radius).

Whilst connectivity ensures that talent and contacts can access Google at King's Cross, the quality of the place plays an equally important role in recruitment and retention. Following a decade of extensive regeneration, King's Cross has established itself as one of London's most popular destinations – with Granary Square a public realm centrepiece, hosting a great cultural programme and surrounded by excellent bars, restaurants and cafes. It was felt by Google that Argent (the property developer) had taken [positive] risks with its events programming and hoped that this would continue in order to retain the buzz about the place. King's Cross is an 'interesting' place to be for Googlers who are surrounded by like-minded people (the workforce and collaborators in other businesses and universities in the area), but also able to benefit from the diversity of the wider area.

Source: Based on an interview with Google conducted as part of the SIA

- 2.5 Flows of **inward investment** into KQ have been a feature of recent years and the example of Google (Box 2-2) is a case in point. Many other examples can be cited (and specific examples are given in the Theme chapters): McKinsey is moving into the area; and the global advertising firm Havas opened its European HQ near King's Cross in February 2017. Explaining the decision, Havas' chief executive commented "*we're at the intersection of the best of technology and the best of creativity*"⁵.
- 2.6 From the official datasets, other types of flows can be evidenced. One of the most important relates to **commuting flows**. Analysis completed by the two councils (based on the 2011 Census) suggests that 91% of those working in Camden lived outside the borough whilst the corresponding figure for Islington was 89%⁶. Cut another way, data from 2011 Census indicate that some 227,000 people commute into Camden and 132,000 into Islington. London borough boundaries have no functional significance in terms of labour markets; most commuters are relatively local (e.g. from adjacent boroughs); and – in many respects – flows of people are core to what defines "city-ness" and processes of innovation within it. But even so, these figures are extreme. The consequence is that both Camden and Islington essentially have two "economies" – one defined around the people who live there (i.e. the council tax payers) and a second defined around the businesses based in the two boroughs (the business rates payers), the jobs they generate and the workers they employ, most of whom live elsewhere.
- 2.7 There are also flows defined in relation to **migration** – particularly in relation to younger people – both nationally and internationally. Talented young people come to London either to study or for their first job(s); and many will move out in their 30s (taking with them their skills, acquired knowledge and accumulation of disposable income). At present, this domestic population net outflow is offset partly (and in some years wholly) by the net inflow of

⁵ "*Inside the Agency: Havas heads to King's Cross*" Digiday UK, 14th March 2017 – see <https://digiday.com/marketing/inside-agency-havas-finds-powerful-neighbors-kings-cross/>

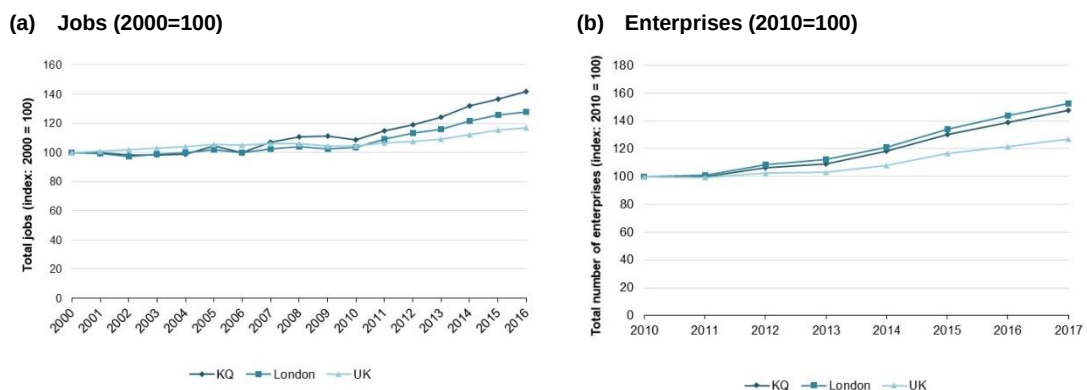
⁶ Census 2011, "Location of usual residence and place of work by method of travel to work"

migrants to London from outside the UK⁷. This dynamic amongst a (mostly) highly skilled workforce is important to the functioning of the Knowledge Quarter's, and London's, economy.

On a workplace view

- 2.8 According to ONS data – and on a workplace measure – Camden and Islington were the 4th and 5th largest of the 33 London boroughs in 2015 in terms of GVA (output) estimates: Camden's GVA was about £26bn, whilst the figure for Islington was around £17bn⁸. GVA per employee job – a broad measure of productivity (although one that neglects self-employment in the denominator) – was estimated at £77.8k in Camden and £77.3k in Islington in nominal terms. For both boroughs, this was similar to the London-wide average (£77.4k) and very much higher than the national average (£58.4k). Moreover, both boroughs have seen impressive recent growth. GLA Economics estimates that between 1997 and 2015, (nominal) GVA increased by 165% in Camden (the 4th biggest increment among 33 London boroughs) and 140% (the 8th biggest change) in Islington. Over this period, London as a whole grew much more quickly than the national economy: it accounted for 18.7% of UK GVA in 1997 and 22.7% in 2015⁹.
- 2.9 Overall, the two boroughs accommodated some 48,000 enterprises in 2017, 9% of the London total¹⁰. On the basis of data from the ONS jobs density dataset, they accounted for 656,000 jobs in 2016 (about 11% of the London-wide total). Over preceding years, both the number of enterprises and the number of jobs grew much more quickly than nationally as the charts below confirm.

Figure 2-1: Recent growth in the number of jobs and the number of enterprises in KQ (Camden and Islington), London and UK



Source: Data from ONS UK Business Counts and ONS Jobs Density statistics, accessed through NOMIS

⁷ For example, at UCL, 54% of employed EU and 38% of other overseas postgraduate research students were working in the UK six months after graduation in 2017. HESA Destination of Leavers from Higher Education Survey, 2016/17 (accessed via UCL)

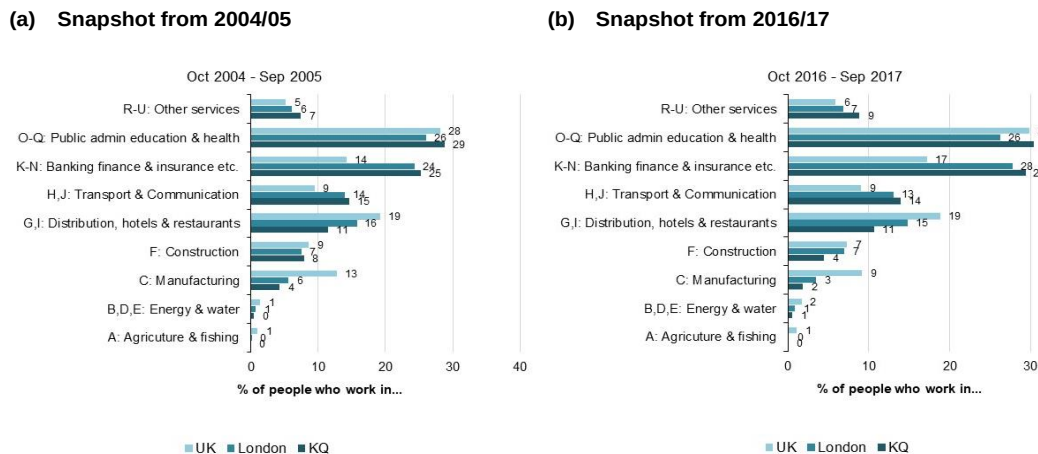
⁸ Experimental Statistics – time series of GVA estimates from 1997-2016 for English local authorities (ONS, 2017)

⁹ These data are taken from "Examining GVA in London's local authorities in a London and UK context, 1997-2005", Gordon Douglass and Irene Sobrevilla-Quiton, September 2017 GLA Economics: Current Issues Note 55. Note that this report states that these estimates are not national statistics.

¹⁰ Data from IDBR, ONS

- 2.10 In the process of growth, the structure of the local economy has changed in sectoral terms (see Figure 2-2). Specifically, there has been very rapid growth in key service sectors (particularly “banking, finance and insurance”) while the number (and share) of both manufacturing and construction jobs has diminished. On this measure at least, manufacturing jobs now account for 2% of workplace jobs in KQ. This pattern has been seen across Inner London, but it is especially pronounced in Camden and Islington.

Figure 2-2: Changing sectoral composition of the economy in Camden and Islington



Source: Annual Population Survey workplace analysis

- 2.11 Camden is ranked second (of 144) in the Grant Thornton Business Index “location” score and for “environment and infrastructure”, and Islington is ranked third for “economic performance”. This business excellence is in sectors that are highly relevant to this Audit (demonstrated by the relative industrial specialisation of the Knowledge Quarter, with high scores for arts, professional and scientific activities, and information and communication).
- 2.12 Camden and Islington are firmly established as major hubs for science and technology jobs. Analysis completed by ONS and reported by GLA Economics suggested that in 2015, Camden had over 110,000 jobs and Islington over 60,000 jobs in these sectors (on a broad definition); and that the two boroughs were ranked 2nd and 3rd respectively (across London) on this metric¹¹. Separately, it has been reported that between 2003 and 2013, Camden saw both the strongest growth in science and technology employees London-wide; and had the highest concentration of such jobs within London¹².
- 2.13 Camden and Islington are also, demonstrably, entrepreneurial. To illustrate the point – and just focusing on Camden in terms of data – there were 6,050 business ‘births’ in Camden alone in 2016, an 11% increase on 2015 and the second highest business births figure in London (after Westminster). Of the Camden enterprises that started in 2011, 41.9% were still active five years later; this was better than the survival rates for Central London and Greater London and by virtue of sheer volume, ranked third nationally for business survival by local authority.

¹¹ See *Economic Evidence Base for London 2016*, GLA Economics – see Figure D1

¹² “*The science and technology category in London*”, Gordon Douglass and Jonathan Hoffman, March 2015. GLA Economics Working Paper 64

Commercial sites and premises

- 2.14 The workplace economy of the KQ is evidently buoyant. This has been translated into significant growth in the office market in recent years through the re-development of King's Cross which will deliver 315,000 sq m of B1 office space¹³, almost all of which has been occupied or is pre-let where unbuilt. Other key developments include The Francis Crick Institute (one of the KQ's principal assets), as well as the intensification and refurbishment of office space along Euston Road. Through a study for Camden Town Unlimited, Volterra estimated that between 2009 and 2015, employment in the area between King's Cross, Euston and Camden Town grew at a rate of 2.2% pa, with the delivery of c. 6,500 new jobs during this six-year period¹⁴. Volterra also observed that vacancy rates, at 2.9% in Q3 2017, were significantly below the GLA's benchmark for a functional market rate (5-8%). The result has been an escalation in commercial property prices; at over £75 per sq ft, King's Cross is now one of the most expensive office markets in London.
- 2.15 More generally, evidence suggests industrial land values of £6.2m per ha in Camden and £7.4m per ha in Islington (compared to a London-wide average of £4.9m). Residential land values are substantially higher (£33m per ha in Camden and £52m per ha in Islington). GLA Economics estimates further that Camden and Islington were ranked 2nd and 9th respectively in terms of the amount of floorspace proposed for conversion to residential use under Permitted Development Rights (to March 2015)¹⁵. **For businesses – including those in science and technology sectors – commercial sites and premises are therefore increasingly expensive, but at the same time, there is enormous pressure to convert employment land to residential uses.**
- 2.16 In parallel, there is evidence that **the nature of demand for commercial premises is changing profoundly**. A London-wide study which was completed in 2015 for example observed that:

London's business geography is undergoing rapid change... Areas that were formerly regarded as fringe locations have effectively acquired prime status such as City Fringe, King's Cross, Paddington and areas of the South Bank. Buildings that would have been described as 'secondary' or 'low grade' in the traditional market, can now command prime rents. Changes in workstyles are being driven by changing priorities of businesses and reflected in evolving workplaces. London's economy is shifting from one dominated by financial services to a more diverse one; with a strong growth in micro and SME firms. These changes are structural, or permanent, rather than cyclical responses to short-term economic cycles.

London is at a pivotal point in its evolution from a service economy dominated by large corporates based in monolithic office blocks, to a more diverse business ecosystem, based in more flexible workspaces with small businesses at its core¹⁶.

- 2.17 The KQ is – arguably – at the geographical core of this transformation and the “embracing of city-ness” in economic life is a motive force.

¹³ From King's Cross Estates – 'about the development'

¹⁴ *Camden Enterprise District: Securing Camden's Inclusive Growth*, Report by Volterra for Camden Town Unlimited, 2018

¹⁵ See *Economic Evidence Base for London 2016*, GLA Economics – see Chapter 4

¹⁶ *Small offices and mixed use in CAZ [London's Central Activities Zone]* Report by Ramidus Consulting to GLA, June 2015 – page 68

Incubators, accelerators and co-working spaces

- 2.18 Particularly for larger corporates, a phenomenon of recent years relates to accelerators; these are nurturing new businesses – and particularly new tech start-ups – under the corporate gaze. A report by Telefonica suggested that 32 of 50 UK accelerators were in London¹⁷.
- 2.19 The provision of **incubators, accelerators and co-working spaces** (IAC) across London was considered through a study commissioned by GLA and LEAP and produced by URS (now part of Aecom) (published by the LEAP as part of the London Open Workspace Forum), as key to supporting an ecosystem of start-up and scale-up SMEs¹⁸. The mapping that accompanied this study has been augmented by desk research and cross-referenced with BEIS' Business incubators and accelerators UK directory (compiled by Nesta, last updated 14 May 2018). The provision within the KQ area has been benchmarked against Tech City (the area around Shoreditch).

Table 2-1: Provision of different forms of workspace

	KQ	Tech City
Incubator	8	4
Accelerator	6	13
Co-working	37	37
TOTAL	51	54

Source: London open workspace group map (GLA/LEAP); business incubators and accelerators UK directory (BEIS/NESTA); and desk research

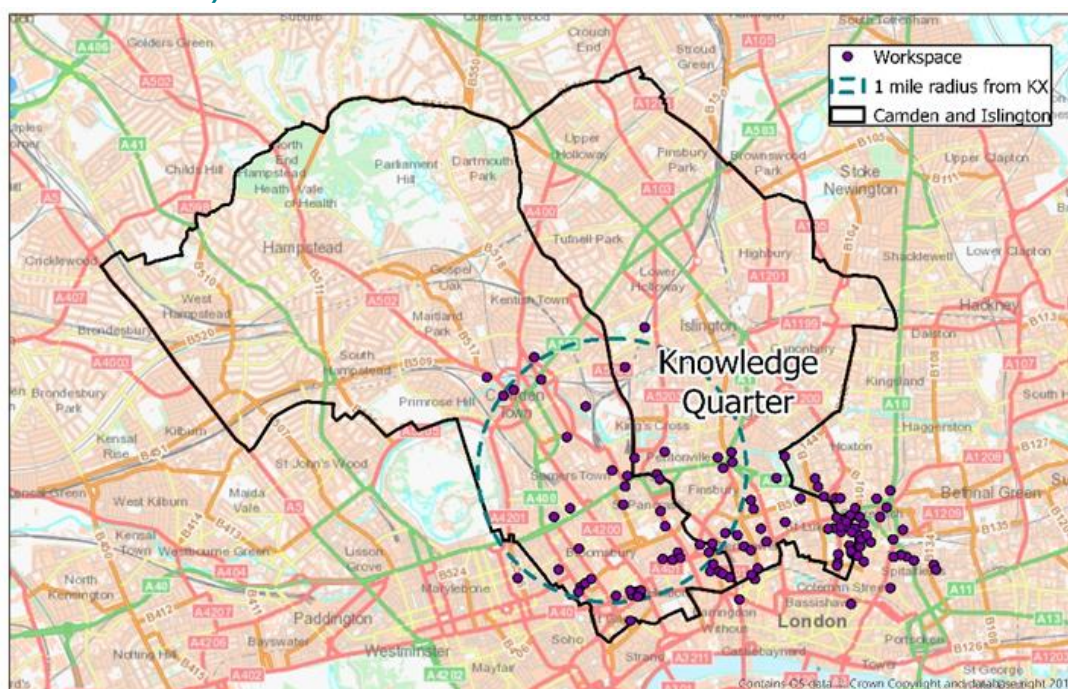
- 2.20 Focusing specifically on **life sciences**, MedCity commissioned a London-wide investigation of physical provision. It identified a shortfall and recommended that there should be: increased provision of small-scale units close to the research base; innovation centre space; grow-on space; and space within or close to hospitals. It noted further that *“from our survey, the most popular location is the area around Euston Road”*¹⁹ (i.e. the heart of the Knowledge Quarter).
- 2.21 The current distribution of managed workspace – of different forms – across (and beyond) the Knowledge Quarter is mapped below. It largely reinforces the findings of the London-wide studies referenced above.

¹⁷ *The Accelerator and Incubator System in Europe*, Telefonica 2013

¹⁸ *Supporting Places of Work; Incubators, Accelerators and Co-working Spaces*, URS/ GLA, 2014

¹⁹ *Planning for Growth: Demand for healthcare R&D space in London* Report to Med City by Creative Places, March 2016

Figure 2-3: Managed workspace within the KQ; close to the KQ; and within Tech City (the area around Shoreditch)



Source: Data sourced from 'London Open Workspace Group map' (GLA/LEAP), 'Business incubators and accelerators UK directory' (BEIS/NESTA), and desk research. Map produced by SQW 2018. Licence 100030994 Contains OS data © Crown copyright [and database right] [2018]

Investment community

- 2.22 Also important to supporting the small business ecosystem and the commercialisation of talent is the investment community. Reinforcing this point, MedCity has stated that the co-location of Venture Capital (VC) is critical to attracting critical mass for a life sciences cluster at King's Cross. Further desk research, combined with the BEIS' Business incubators and accelerators UK directory gives an indication of the location of investor community with a particular focus on the SIA's core themes. This has, again, been benchmarked with Tech City, but also with the West End (which is considered the traditional centre for investment funds).

Table 2-2: Understanding the investor community in different parts of London

	KQ	Tech City	West End
VC	14	7	34
Angel	2	3	1
Other (seed, syndicate)	1	3	0
TOTAL	17	13	35

Source: Business incubators and accelerators UK directory (BEIS/NESTA) and desk research

Conclusions in relation to commercial property

- 2.23 The data show that the **scale** of overall co-working and incubator provision in KQ and Tech City is not dissimilar, but the **composition** and **density** are different
- 2.24 Incubator numbers are slightly higher in KQ area (after accounting for those attached to a university), but accelerator numbers are much greater in Tech City. There are examples of VCs

based in workspaces mapped above but this is not immediately obvious to those looking for them/looking for workspace – **more could be done to improve the visibility of the provision available for entrepreneurs and SMEs.** There are similar numbers of VCs and Angels in KQ and Tech City, but a significantly higher concentration in the ‘West End’ (the Soho and Westminster areas). The concentrations of activity in the West End and Tech City are in close proximity to the KQ. But it is evident that, when looking at specific provision for life and data sciences – compared to say tech, generically – **There is no clear concentration in the KQ area, particularly at the locus of activity around King’s Cross.**

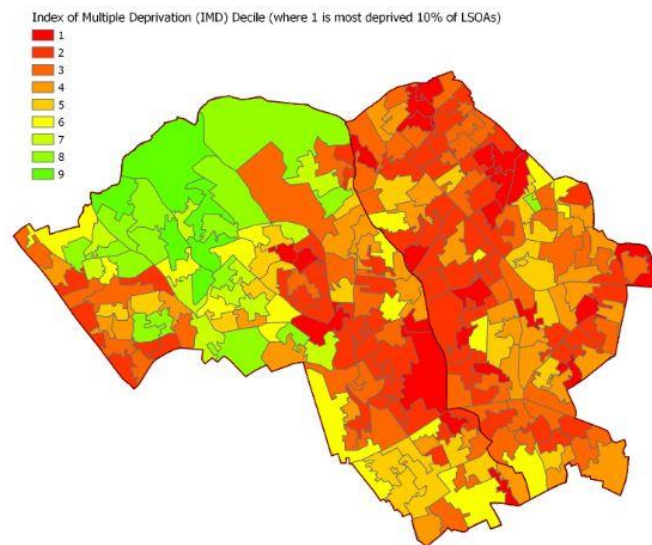
- 2.25 From these different studies and the evidence gathered locally, it is apparent that **the density of provision is higher to the east of KQ (in the area around Old Street/Shoreditch/Silicon Roundabout); and specialist provision is especially limited in the immediate vicinity of the key science and knowledge assets that are mapped in subsequent chapters.** Overall, the availability and cost of appropriate commercial sites and premises is having a bearing on the capacity of the KQ to commercialise its science and knowledge-based assets *in situ*. This is an issue to which we return repeatedly throughout this SIA report.

On a residence-based view

- 2.26 Overall, Camden and Islington are home to about 481,000 people (over 5% of the London total). Of these, well over 70% are of working age (aged 16-64) – a higher proportion than for London and nationally (signifying, in practice, a relatively young population overall). Among those aged 16+, activity rates are similar to national benchmarks but it is important to note that students are defined as “economically inactive” (and large numbers of students are resident in both boroughs). Patterns of economic activity are distinctive; particularly in Camden, the incidence of self-employment is relatively high (six percentage points higher than the national average). Both boroughs have a high incidence of well-qualified residents: close to 60% of the working age population is qualified to degree level or higher (around 20 percentage points higher than the national average). Overall, the residents of Camden and Islington can be characterised as relatively young and well-qualified²⁰.
- 2.27 However, this borough-wide summary is in danger of masking significant social and economic issues and challenges. There are areas of acute deprivation in both boroughs. The map below – based on data from the overall Index of Multiple Deprivation (2015) – provides an important summary. It shows clearly that at a granular scale, both boroughs can point to some of the most – and least – deprived parts of the UK. Locally, wards such as St Pancras and Somers Town, and Regent’s Park have significant levels of poverty, and there are real challenges relating to labour market inclusion. At the same time, the KQ’s diverse socio-economic mix (supported through – for example – housing policy) is an important part of its character and vitality.

²⁰ Data from ONS, including Annual Population Survey (Jan-Dec 2017), sourced through NOMIS

Figure 2-4: Patterns of deprivation and disadvantage across Camden and Islington – based on data from the overall Index of Multiple Deprivation, 2015



Source: data from the Index of Multiple Deprivation mapped by SQW (Licence 100030994 Contains OS data © Crown copyright [and database right] [2018])

- 2.28 It is important to recognise that young people growing up in the Knowledge Quarter may not be well-equipped to take up the jobs generated through the area's scientific and cultural organisations/institutions, or its businesses. For example, although a larger proportion of Camden school students go on to higher education than the national average, fewer go on to Russell Group universities than in inner London or the national average. Students from disadvantaged backgrounds, and young males in particular, underperform in university admissions. There are, in addition, particular challenges in relation to the local provision of skills in science, technology, engineering, arts and maths (STEAM) – an issue that has been recognised through Camden's STEAM Commission²¹.

Conclusion

- 2.29 Camden and Islington have demonstrably seen substantial growth, including in sectors which define the core of this SIA. However, there is also evidence that the area is under pressure. The supply of commercial premises that are appropriate for the needs of small and growing knowledge-based businesses – and are reasonably proximate to the major science and knowledge-based institutions – is an immediate concern. There is much evidence to suggest a shortfall currently and this in itself is creating constraints in relation to the full possibilities of the area's science- and knowledge-based assets, and the processes and impacts of innovation (as defined through our first and third SIA hypotheses).
- 2.30 Although beyond the scope of an SIA, it is important also to recognise that there are substantial housing market issues across both boroughs. Whilst there is pressure to convert employment sites and premises for residential uses, the cost of housing (in terms of house prices and rental levels) has continued to escalate. In September 2017, the average house price in Camden was £862,606, 1.8 times higher than Greater London and 3.6 times that for England & Wales. The median house price to earnings ratio was 21.5 (up from 10.6 in 2006). In Islington, the average house price was £616,442, and the median house price to earnings

²¹ *Creating Camden's 21st Century Talent – STEAM Commission Report* (Camden Council, June 2017)

ratio was 16.4. Rent is 86% of the median income in Camden, and 77% of the median income in Islington²².

- 2.31 The escalation in house prices is clearly affecting households on low incomes (of which there are many). But it is also affecting many of those that comprise the KQ's knowledge-based workforce. It is important to recognise that lab technicians, post-doctoral researchers, university lecturers, museum curators and freelance software engineers are not in the main "well paid" – certainly not by City of London standards. In this context, for many, there may in practice be little real alternative to long distance commuting on an overcrowded railway network (both over-ground and underground). Integrating housing, transport and 'place making' is therefore a key issue for the Knowledge Quarter, London as a whole and the UK in seeking to work its asset base harder.
- 2.32 Finally, it is important to acknowledge that local residents may also struggle to contribute fully as part of the Knowledge Quarter's workforce. Both boroughs are very diverse in socio-economic terms. Areas of significant poverty and disadvantage exist alongside more affluent wards and more could be done to increase educational attainment and access to the labour market for local residents.

²² Land Registry – Transactions in the period 1st Jan 2008 – 31st March 2018; and Annual Survey of Hours and Earning (ASHE, ONS – sourced through NOMIS)

3. Strengths in science and innovation

Chapter Summary:

KQ has substantial strengths across its science and knowledge-based institutions. University College London (UCL) is one of the largest universities in the UK and it is close to the top of every league table of relevance to the SIA. KQ also benefits from smaller higher education institutions which are defined around clearly defined specialisms including, for example, the Royal Veterinary College (RVC) and London School of Hygiene and Tropical Medicine (LSHTM).

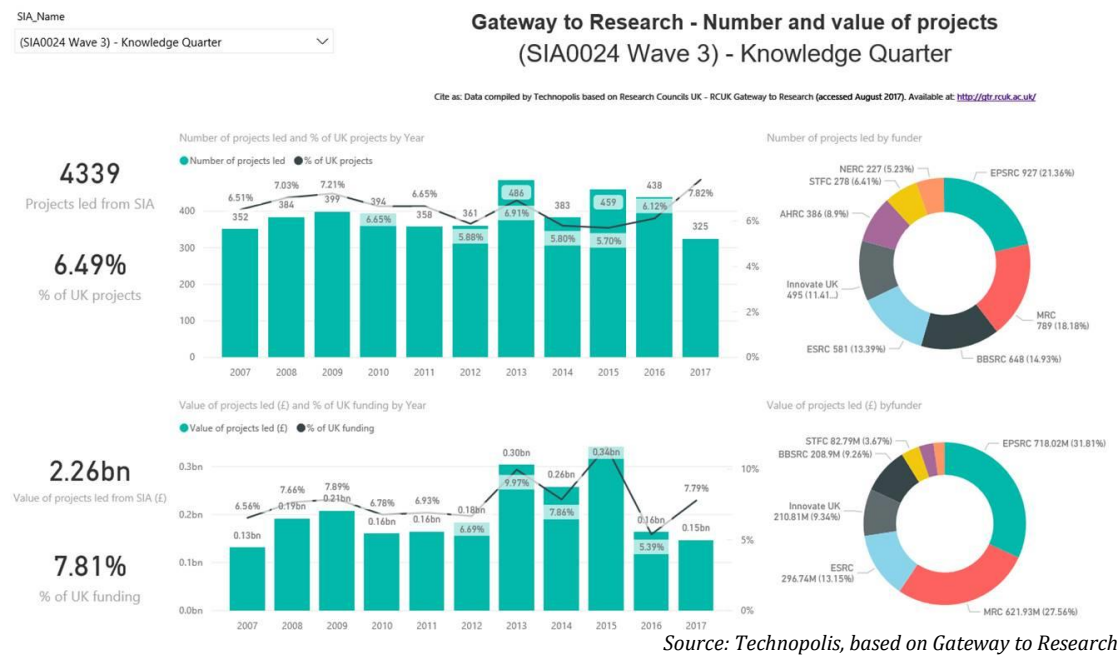
But the Knowledge Quarter is not simply about universities and their research and teaching excellence. There is a complement of outstanding research institutions – ranging from the Alan Turing Institute to The Francis Crick Institute. There are also national organisations such as the British Library and British Museum which are substantial knowledge hubs. Finally, it is important to recognise the importance of businesses in KQ, some of which have been attracted in by the depth and breadth of science, knowledge and innovation assets whilst others have been generated locally.

Excellence in science and research

- 3.1 The Knowledge Quarter has a substantial depth of scientific, knowledge and research excellence. It has been winning Nobel Prizes in science for over a century; this has reflected Professor Sir William Ramsay's early work in chemistry through to Professor John O'Keefe's discovery of cells that constitute a positioning system in the brain, some 110 years later. At the same time, it has been a major focus for the arts and during the first half of the 20th Century, it was home to the Bloomsbury Group of writers, intellectuals, philosophers and artists (including Virginia Woolf, John Maynard Keynes, E. M. Forster and Lytton Strachey). Much more recently, it has generated literally world-changing science, as this Audit goes on to explain.
- 3.2 The *Global Research Identifier Database (GRID)* identifies 296 research organisations in the Knowledge Quarter. One insight into the character and scale of the associated asset base can be taken from Research Councils UK's *Gateway to Research* database²³. This provides an indication of the scale of UK research funding that is accounted for by organisations in KQ.

²³ The data reported here were accessed by Technopolis in August 2017

Figure 3-1: Number and value of research projects within KQ



3.3 It also lists “research active” organisations according to the “number of participations” in funded research projects. It is a very imperfect metric²⁴. Nevertheless, four points are particularly striking from Table 3-1:

- First, it is clear that the KQ’s list of research participations is built up from a substantial number of different organisations
- Second, within this, one institution – University College London (UCL) – accounts for 48% of the KQ’s total number of “research participations” while the second biggest contributor (London School of Hygiene and Tropical Medicine (LSHTM)) is a full order of magnitude smaller. In part, this obviously reflects the breadth of the two institutions, but it is worth putting the scale of UCL in sharper focus: looking across the whole of the UK-wide database, UCL is the organisation that tops the list²⁵.
- Third, within the “top 25”, 10 different universities feature, but it is actually “other institutes/organisations” that account for the largest number of entries. These vary from major charities (like The Wellcome Trust) to independent research organisations (such as IFS and NatCen) and to major institutions (such as the British Library and British Museum).
- Fourth, it is apparent that organisations captured in Table 3-1 vary tremendously in terms of longevity. As alluded to in Table 1-1(see Chapter 1), the British Museum was founded in 1753, the University of London in 1836 and The Francis Crick Institute was created in 2015; all three of these institutions feature prominently in this SIA report.

²⁴ This is partly because it is inconsistent in terms of naming conventions and partly because the “address” attached to organisations may not be the location at which research is taking place. This is a particular problem for the KQ given the high incidence of registered addresses in central London

²⁵ On this metric, University of Oxford comes second (3,396) and University of Cambridge is third (3,087).

Table 3-1: Top 25 “research active” organisations in the KQ from Gateway to Research (with “number of participations”), by type

University	Private sector business	Other institutes/organisations
University College London (3,502)	Arup Group Limited (171)	The Wellcome Trust (111)
London School of Hygiene and Tropical Medicine (343)	Johnson Matthey Ltd (164)	Institute for Fiscal Studies (63)
Birkbeck College (207)	Network Rail (99)	British Library (62)
City University of London (187)		English Heritage (52)
Royal Veterinary College (161)		Age UK (45)
Institute of Education, University of London (118)		National Centre for Social Research (41)
University of London (100)		British Museum (40)
School of Oriental and African Studies (93)		Rail Standards and Safety Board (31)
University of the Arts London (70)		Arts Council England (28)
London Metropolitan University (35) ²⁶		Food Standards Agency (28)
		Imperial Cancer Research Fund (27)
		Francis Crick Institute (27)

Source: Data from Gateway to Research sourced by Technopolis and accessed in August 2017

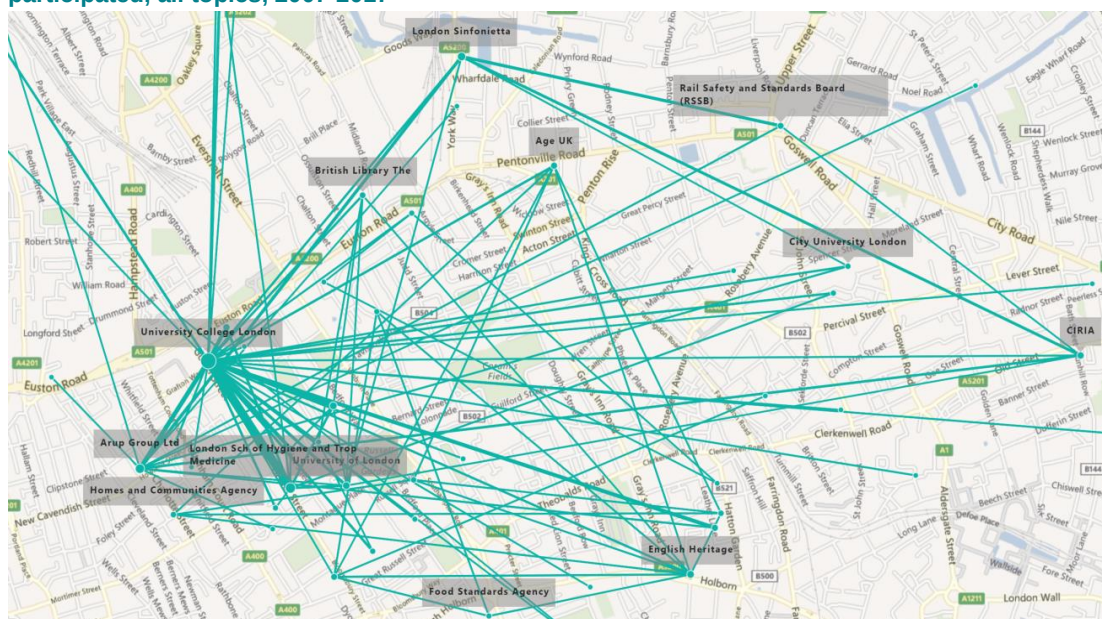
- 3.4 A premise underpinning the SIA is that the strength of the KQ rests in the close juxtaposition of all these different organisations and the links – both formal and informal – that have developed between them. “Links” are very difficult to measure. At a high level, some insight into them was provided by an experimental mapping of collaboration networks – using semantic analysis (reflecting the three Themes/sub-Themes) and based on data from *Gateway to Research* – which was completed by Technopolis²⁷. The authors themselves acknowledge that the methodology has some limitations²⁸. Nevertheless, it clearly shows that UCL is a very major node in the networks of collaborations, but there are other smaller nodes too – ranging from LSHTM to the British Library to Age UK and the other universities in the Knowledge Quarter.

²⁶ London Metropolitan is within the London Borough of Islington but outside the core area that we are describing as the Knowledge Quarter

²⁷ *Knowledge Quarter Science and Innovation Audit: Analysis and Assessment of Research Capacity*, Technopolis – March 2018

²⁸ These relate, for example, to the dependence on data which extend back to 2007 and therefore may underplay the current relative role of newer institutions such as the Alan Turing Institute and The Francis Crick Institute

Figure 3-2: Network of collaborations for organisations in the KQ geography, number of grants participated, all topics, 2007-2017



Source: Technopolis, based on Gateway to Research data

3.5 More qualitative insights were provided through the SIA “Call for Evidence” – and specific examples of cross-Theme collaborations are provided in Box 3-1.

Box 3-1: Examples of collaborations between organisations in the KQ which are cross-Thematic in character

- **London Metropolitan Archives** worked with the **London School of Hygiene and Tropical Medicine** on an activity with school children about the spread of infectious diseases
- **London School of Hygiene and Tropical Medicine** worked with **LMA** on public engagement events in connection with the Mapping and Imaging Smallpox project funded by the **Wellcome Trust**
- Academic staff at **Birkbeck** are working closely with cultural organisations in KQ. For example, Leslie Topp curated an exhibition at the **Wellcome Collection** and Lynda Nead (a V&A Trustee) curated an exhibition at the **Foundling Museum**
- Based around a strategic partnership between **Central Saint Martins** and **Camden Council**, the Public Collaboration Lab (PCL) works collaboratively with a variety of local organisations including **Camden Council**, **Somerstown Community Association**, **LGIU**, **Islington Council**, and the **Living Centre (at the Crick)**
- The **Bloomsbury Centre for Bioinformatics** is a collaborative venture between **UCL** and **Birkbeck** which spans disciplines such as protein structure prediction and classification, genomic and transcriptomic data analysis, statistical genetics and systems biology
- **Birkbeck** researchers have developed a research tool for digital humanities which is currently being used by the **British Library** and **Wellcome Trust**
- Through the **Digital Music Lab** project, **City, University of London's** Machine Learning Group is working with **UCL** and the **British Library**, alongside Queen Mary University, to develop research methods and software infrastructure to explore and analyse large scale music collections

Source: Based on information submitted to the KQ SIA Consortium as part of the “Call for Evidence”

3.6 In the paragraphs below, we comment briefly on the breadth and depth of the Knowledge Quarter’s assets. The role of individual organisations is considered in considerably more detail in the three Theme-focused chapters which follow.

Key institutions within the Knowledge Quarter

Universities

- 3.7 Within the context set out above, UCL is the largest player in relation to higher education institutions across the Knowledge Quarter – and it features extensively in the rest of this SIA. It is internationally significant, and it ranks well when considered alongside the world's leading universities as the data in Table 3-2 overleaf demonstrate.
- 3.8 The other higher education institutions within the Knowledge Quarter are, in the main, more specialist – either as a function of their overarching mission (e.g. Birkbeck has long had a focus on adult students from diverse backgrounds and agendas relating to widening participation) or because of a very distinctive subject focus which effectively defines their purpose (and is generally captured in their name). For the Knowledge Quarter as a whole, what matters is what this adds up to.
- 3.9 Scanning through Table 3-2 suggests:
- a depth of research expertise in the arts and humanities, economics and business *as well* as in the subjects that define the core of this Science and Innovation Audit
 - collaborative research income in excess of £120m (in 2016/17)²⁹
 - contract research income of more than £100m (in 2016/17)
 - almost 500 REF impact case studies – which was more than the figure for seven (of nine) whole English regions (and provides some indication of the extent to which research in the KQ's universities is finding commercial application).
- 3.10 From the table, it is also evident that the universities within the Knowledge Quarter are responsible for a substantial student body. In 2016/17, this numbered almost 100,000 in total. Whilst not all students will be resident locally (even in term time), the vibrancy linked to student numbers on this scale needs to be recognised as an asset in its own right: the KQ is a magnet for (in the main) young and inquisitive people.

²⁹ Note that these data are taken from the HE-BCI Survey (which only captures a portion of each institution's total income from RG&C), as opposed to data taken from the institutions' own accounts. As such, the total we are reporting here for collaborative research income is probably about one-quarter of institutions' overall income from RG&C. In 2016/17 this well have been something like £450-500 million (for all HEIs in the KQ, of which UCL and LSHTM accounted for the majority).

Table 3-2: Breadth and depth of research excellence in the KQ's major universities, and perspectives on scale

Institution	REF: Overall top 3 units of assessment in terms of the proportion of outputs rated as 4* (i.e. research of a quality that is world-leading in terms of originality, significance and rigour)	REF: Other units of assessment with at least 10% of outputs rated as 4*	No. of REF Impact Case Studies	REF 2014 overall ranking on GPA / Research Power	Students, 2016/17 (and % that were international)	Collaborative research income, 2016/17 (and 2015/16)#	Contract research income, 2016/17 (and 2015/16)#	Times Higher Education World University Ranking – Globally (and in UK)	Complete University Guide – overall UK ranking
Birkbeck College	Psychology, Psychiatry and Neuroscience (60%) Biological Sciences (joint submission with University College London) (46%) History (35%)	10	67	46 / 48	12,915 (10%)	£470,000 (£231,000)	£82,000 (£136,000)	301-350 (39=)	116
City University London	Business and Management Studies (41%) Music, Drama, Dance and Performing Arts (34%) Communication, Cultural and Media Studies, Library and Information Management (33%)	8	49	49 / 43	19,405 (39%)	£5.5m (£6.1m)	£1.5m (£2.5m)	351-400 (48=)	42
London School of Hygiene & Tropical Medicine (LSHTM)	Public Health, Health Services and Primary Care (43%) Clinical Medicine (40%)	0	22	10 / 46	1,345 (48%)	£56.1m (£47.1m)	£10.5m (£8.6m)	NA	NA
Royal Veterinary College (RVC)	Agriculture, Veterinary and Food Science (35%)	0	11	6 / 3	2,375 (15%)	£2.6m (£1.2m)	£4.0m (£3.4m)	351-400 (48=)	NA
School of Oriental and African Studies (SOAS)	Music, Drama, Dance and Performing Arts (44%) Art and Design: History, Practice and Theory (35%) Theology and Religious Studies (29%)	8	33	61 / 63	6,360 (42%)	£55,000 (£0)	£434,000 (£56,000)	401-500 (53=)	38
University College London (UCL)	Economics and Econometrics (79%) Computer Science and Informatics (61%) English Language and Literature (52%)	33	283	8 / 1	37,905 (42%)	£57.5m (£72.0m)	£89.1m (£89.4m)	16 (4)	7
University of the Arts London	Art and Design: History, Practice and Theory (31%)	0	12	4 / 1	18,290 (47%)	£1.0m (£0.8m)	£114,000 (£42,000)	NA	83

Source: REF 2014 (Note GPA=Grade Point Average); HESA 2018; Times Higher Education World University Rankings, 2018; Complete University Guide – University League Tables 2018.

Data sourced in April 2018

#In some cases, figures for 2015/16 and 2016/17 are very different (suggesting year-on-year volatility). Where this is the case, the earlier year's figures are shown in parentheses for comparative purposes.

- 3.11 It is important to recognise also that the Knowledge Quarter's higher education institutions play a role as a source of new businesses: data from the Higher Education Statistics Agency (HESA) show that in 2016/17, the KQ HEIs generated 362 spin-off and start-up companies³⁰.

Research organisations/institutions

- 3.12 Alongside the universities – and partly as a consequence of them – the Knowledge Quarter benefits from a range of research organisations/institutions, some of which were included in Table 3-1 above. These are typically independent of particular universities, but they tend to have very close research-based links to them and also to the major funding bodies (such as the research councils and/or the major charities). Again, these are considered in more detail later in this report, but key examples include: **the Alan Turing Institute, The Francis Crick Institute and the Farr Institute of Health Informatics Research.**

Major cultural organisations/institutions

- 3.13 One piece of the organisational architecture which sets KQ apart is the presence within it of major cultural organisations/institutions. These are substantial knowledge hubs in their own right and whilst their focus is broader than “science”, their role as guardians of substantial, internationally-significant, cultural and scientific collections is considered in detail as one of our three Themes. Major actors in this field include: the **British Library and the British Museum** (both of which have Independent Research Organisation status, making them eligible for Research Council funding); **London Metropolitan Archives**; and the **Wellcome Collection**. There are also many smaller organisations, ranging from the **Foundling Museum** to the **Charles Dickens Museum**.

Businesses

- 3.14 Understanding the relationship between the Knowledge Quarter as a “place” and its business community is complex. It is within central London and partly for that reason, it hosts the registered addresses of many knowledge-intensive businesses. Some of these are no more than “addresses” (with little or no physical presence); some will have their head office functions inside the Knowledge Quarter (but not much else); while some will (in addition) locate most or all of their research and innovation functions locally. Examples of large companies with a substantive knowledge and/or R&D presence physically within the Knowledge Quarter include **Google, DeepMind, and Benevolent AI**.
- 3.15 As discussed in the context of individual Themes, the Knowledge Quarter is also home to some highly innovative and entrepreneurial small businesses. Some of these are related to the higher education institutions, formally or informally. Others have gravitated to the area to be part of the network of linkages that exists. Many are “pre-revenue” and, particularly in life sciences, many are very dependent on research grants and collaborations.

Major charities

- 3.16 The major charities have a crucial – if insufficiently acknowledged – role in relation to the landscape of science and innovation across the UK. Some are physically based within the

³⁰ HESA, HEBCI (2018)

Knowledge Quarter. Again, this is partly a function of “being central London”, but it does add to the breadth and depth of institutional assets and expertise. The **Wellcome Trust**, the **RNIB** and the **British Heart Foundation** are examples from the medical sphere.

Major hospitals

- 3.17 Within KQ, there is also a group of major hospitals – from **University College Hospital** (which is closely associated with UCL) to **Great Ormond Street Hospital** and **Royal Free Hospital**. These are a core part of the area’s science and innovation asset base and they play a key role, particularly in respect of life sciences.

Other national and international organisations

- 3.18 Finally, the Knowledge Quarter is also home to a number of other organisations which play an important local role whilst simultaneously being national players. Key examples include the **Digital Catapult**, **EIT International**, the **Design Council** and various **learned societies**. For example, six learned societies (including Microbiology Society, Royal Society of Biology and the Society of Applied Microbiology) are co-owners of Charles Darwin House in Camden (WC1).

Conclusion

- 3.19 The discussion in this chapter has demonstrated something of the breadth and depth of scientific and knowledge-based assets, and innovation capacities that exist within the Knowledge Quarter and – through the semantic analysis completed by Technopolis – the research-based links that exist between them.
- 3.20 The significance of the scientific and knowledge-based endowment that exists within the Knowledge Quarter is hard to overstate. What is much less clear, however, is how the Knowledge Quarter is really performing in relation to the three hypotheses at the core of this SIA. Summarised in Figure 1-3, these are much less about the scale of the scientific asset base than the processes through which it is translated into outcomes and impacts of wider benefit. The three chapters that follow consider, in far more detail, the nature of these processes within each of our three main SIA Themes.



4. Theme 1: Life sciences

Chapter Summary:

The KQ's assets in relation to life sciences are of outstanding. Alongside major London teaching hospitals, UCL, LSHTM and RVC conduct world-class research in the field; and these strengths have been increased further over recent years with the opening of The Francis Crick Institute. The volume of research is substantial and the impacts from it are seen around the world, particularly in the three life science specialisms at the heart of the SIA: dementias, emerging infectious diseases including anti-microbial resistance and musculoskeletal pathology associated with ageing. There are numerous research collaborations, some within the KQ but many more with a footprint that is international or national in scope.

The narrative in relation to commercialisation and innovation is also strong, but – given the scale of market opportunity – there is evidence to suggest it is underpowered compared to the strength of the asset base. In large part, this is because there is a shortage of physical provision within KQ, particularly for small life science businesses seeking affordable wet lab space close to the major research institutions. The only facility within KQ is London Bioscience Innovation Centre and this is full with a waiting list. Some small life sciences businesses have found solutions outside of London (and where this “makes sense”, it is to be encouraged) and some have forged arrangements with, for example, hospitals with lab space. But there is a need for more and better solutions. Developers appear to be interested in the possibilities and it will be important that the opportunities are properly unlocked, recognising that development in Camden and Islington needs to be done appropriately and well.

Scope and links to our hypotheses

- 4.1 Life sciences is one of the principal strengths of the Knowledge Quarter. The KQ is home to three of the UK's leading universities in the field; to major teaching hospitals (notably University College London NHS Hospitals Foundation Trust); to specialist funding bodies with a substantial interest in life sciences (e.g. The Wellcome Trust); to small, innovative, companies; and to a major new research institution which itself is a strongly collaborative venture (The Francis Crick Institute).
- 4.2 The three hypotheses that are shaping the SIA as a whole apply fully to the Life Sciences Theme. Through it, the KQ consortium has sought to explore the strength of the area's scientific assets and innovation capabilities – and particularly the nature of innovative collaborations within and beyond KQ – in respect of three key specialisms:
- emerging infectious diseases, including antimicrobial resistance
 - musculoskeletal pathology (arthritis, osteoporosis) associated with ageing
 - various types of dementia.
- 4.3 Of the three, the first constitutes a key threat to global public health – and many of the gains of recent decades (including in developing countries) are at risk of being reversed by it. Antimicrobial resistance (AMR) threatens the prevention and treatment of infections. Globally, greater drug resistance is complicating the treatment of diseases like tuberculosis, malaria and HIV/Aids; it is increasing substantially the risks associated with surgery which had come to be regarded as routine (e.g. hip replacements); and it is complicating further already-complex procedures such as organ transplantation³¹. The extent of the global threat represented by AMR has been summed up in a report by OECD. It states:

³¹ *Antimicrobial Resistance – Fact Sheet* World Health Organisation, updated January 2018

All countries, regardless of their economic situation, the strength of their health systems or the level of antibiotic consumption, will face disastrous consequences if the spread of AMR is not contained. The modern healthcare that people in high-income countries take for granted, and that those in lower-income countries aspire to, is at stake as medicine and surgery (e.g. organ transplants, cancer care and care of premature babies) are not possible without effective antimicrobial medicines³².

- 4.4 The second and third specialisms considered within the Life Sciences Theme link clearly to the process of population ageing. This constitutes a major demographic change. It is widely identified as a “mega trend” with profound – and wide ranging – consequences; and it features prominently within the Industrial Strategy White Paper as one of the four “*Grand Challenges*”. The changing incidence of ill health is one consequence. Nationally, it has been estimated that the number of cases of dementia will rise from 940,000 in 2021 to more than 1.7 million in 2051, while “*chronic conditions affecting the heart, musculoskeletal and circulatory systems are also more prevalent in old age*”³³. Globally, on another estimate, whereas today some 46 million people live with dementia worldwide, this number is expected to increase to 131.5 million by 2050³⁴.
- 4.5 All three considerations within the Life Sciences Theme are then of considerable national and international significance.

National and international trends, and size of global markets

- 4.6 The corollary of these general observations is that all three specialisms are associated with large – and growing – markets that are genuinely (and increasingly) global.
- 4.7 It has been estimated that the total worldwide cost of dementia was US\$ 818 billion in 2015, rising to US\$ 1 trillion in 2018 and US\$ 2 trillion in 2030³⁵. The process of population ageing underpins this growth but, importantly, the fastest rates of increase are being seen in countries that are still regarded as “developing”. The “cost” of dementia – particularly when that cost is falling disproportionately on developing nations – does not translate straightforwardly into market growth (for there are substantial market failures). Nevertheless, on one estimate, the global Alzheimer’s Disease market was worth \$2.9bn in 2016 and was “*set for double-digit growth with forecast sales of \$14.8bn by 2026*” (equivalent to a growth rate of 17.5% per annum)³⁶. Another estimate was less bullish although still strong; it suggested that the “*global dementia and movement disorders treatment market*” would grow at over 4% per annum from 2017-2021³⁷. The precise numbers are less important than the overall message: the market for therapies and treatments linked to dementia is both large and growing quickly.

³² “*Tackling antimicrobial resistance; ensuring sustainable R&D*” Final note prepared by OECD, WHO, FAO and OIE, 29th June 2017

³³ “*Future of an Ageing Population*” Published by Government Office for Science / Foresight (2016) – page 77

³⁴ *World Alzheimer Report 2015: The Global Impact of Dementia* Published by Alzheimer’s Disease International, 2015

³⁵ *World Alzheimer Report 2015: The Global Impact of Dementia* Published by Alzheimer’s Disease International, 2015

³⁶ “PharmaPoint: Alzheimer’s Disease – Global Drug Forecast and Market Analysis to 2026” – press release (published on GlobalData Healthcare’s website – 10th October 2017)

³⁷ Report by Business Wire (24th July 2017), drawing on a study published by Technavio

- 4.8 The size of the global market linked to AMR is more difficult to gauge. There is clearly a substantial – and urgent – need, but a report by the OECD emphasises the nature of the market failures. It states that “*The research and development pipeline for new antimicrobial therapies has been drying up due to scientific challenges, high uncertainty and low revenues, making such products less attractive as investments for industry*”³⁸. It reports that the number of big pharma companies which are active in the field has declined from 18 in 1990 to 6 in 2016 (mainly because of insufficient returns). And while smaller companies have accounted for a growing share of new drugs, these “*often lack the capital necessary to take a promising idea from initial research through to the late-stage clinical trials required for market approval*”³⁹. Given the scale of the threat, OECD calls for a radical approach to reactivating the R&D pipeline.

Local science and innovation assets

- 4.9 Data from the 2014 Research Excellence Framework are no more than a starting point in seeking to understand the depth of the KQ’s scientific assets in respect of Life Sciences. However, they are impressive. They suggest that on metrics of either research quality or research power, four institutions have one of more “Units of Assessment” in the top five nationally. London School of Hygiene and Tropical Medicine (LSHTM) is ranked first and UCL second in “public health, health services and primary care”; this is very germane to emerging infectious diseases and AMR, as are the credentials of RVC in relation to animal health. UCL is the highest ranking university nationally with respect to research power in “psychology, psychiatry and neuroscience” (and also “clinical medicine”), consistent with the SIA’s focus on dementia.

Table 4-1: Research Excellence Framework 2014: UK rankings in Units of Assessment of relevance to the Life Sciences Theme

	Agriculture, Veterinary and Food Science		Allied Health Professions, Dentistry, Nursing and Pharmacy		Clinical Medicine		Biological Sciences		Psychology, Psychiatry and Neuroscience		Public Health, Health Services and Primary Care	
	Quality	Power	Quality	Power	Quality	Power	Quality	Power	Quality	Power	Quality	Power
Birkbeck College	-	-	-	-	-	-	11	32	5	25	-	-
City University London	-	-	37	9	-	-	-	-	47	29	-	-
London School of Hygiene & Tropical Medicine	-	-	-	-	16	22	-	-	-	-	11	1
Royal Veterinary College	14	3	-	-	-	-	-	-	-	-	-	-
School of Oriental and African Studies	-	-	-	-	-	-	-	-	-	-	-	-

³⁸ “*Tackling antimicrobial resistance; ensuring sustainable R&D*” Final note prepared by OECD, WHO, FAO and OIE, 29th June 2017

³⁹ “*Tackling antimicrobial resistance; ensuring sustainable R&D*” Final note prepared by OECD, WHO, FAO and OIE, 29th June 2017 – page 14

	Agriculture, Veterinary and Food Science		Allied Health Professions, Dentistry, Nursing and Pharmacy		Clinical Medicine		Biological Sciences		Psychology, Psychiatry and Neuroscience		Public Health, Health Services and Primary Care	
University College London	-	-	11	14	9	1	11	3	13	1	7	2
University of the Arts London	-	-	-	-	-	-	-	-	-	-	-	-

Source: Hefce Research Excellence Framework, 2014

- 4.10 Using data from *Gateway to Research*, Technopolis completed a semantic analysis to understand research participations (by value and volume) linked far more precisely to the sub-Themes within the ambit of Life Sciences. Owing to its “newness”, this analysis underplayed the significance of The Francis Crick Institute, but even so, it found that KQ organisations were “lead organisations” in around 12% of publicly-funded research projects in each of the three sub-Themes. In two cases (emerging infectious diseases and dementia) the value of projects led from within the KQ accounted for just under 20% of all funding awarded by the UK Research Councils and Innovate UK since 2007 – signalling the huge significance of the area’s scientific research in these fields, and its role as an ‘incubator for the UK’.

Table 4-2: SIA organisations as a lead organisation in grants, 2007-17

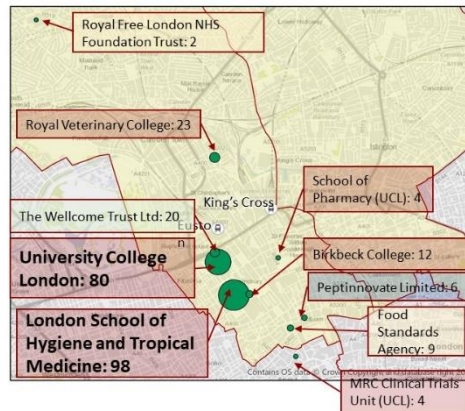
	Number of projects led from the SIA	% of UK projects	Value of projects led from SIA (£m)	% of UK funding
Emerging Infectious Diseases	171	11.5%	131.55	17.4%
Musculoskeletal pathology	55	12.4%	31.63	11.5%
Dementia	107	12.2%	112.88	18.0%

Source: Technopolis, based on Gateway to Research data

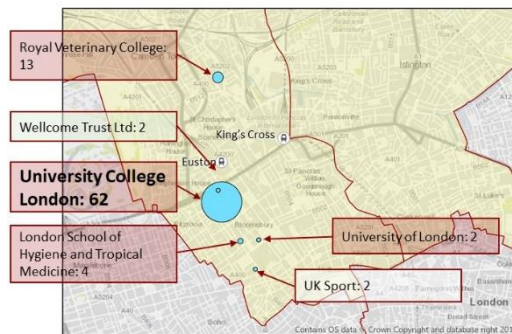
- 4.11 The pattern of “research participations” is mapped in Figure 4-1 (for the larger players). It shows that in the field of “Emerging Infectious Diseases”, LSHTM is the biggest player, followed by UCL. In the other two domains, UCL dominates the picture, by some margin (although noting again that this analysis underplays the role of newer organisations such as The Francis Crick Institute).

Figure 4-1: Semantic analysis of GtR “research participations” across the key sub-themes within Life Sciences, 2007-17

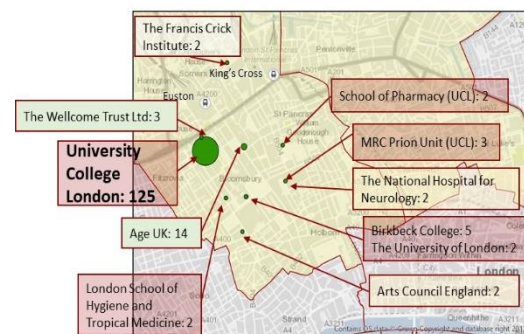
1: KQ Research participations in “Emerging Infectious Diseases”



2: KQ Research participations in “musculoskeletal” fields



3: KQ Research participations linked to “Dementia”



Source: Produced by SQW 2018. Licence 100030994 Contains OS data © Crown copyright [and database right] [2017]

- 4.13 Within this overall context, the table below attempts to summarise the KQ’s principal research strengths within the three Life Sciences sub-Themes.

Table 4-3: Key KQ research strengths in relation to the three Life Sciences sub-Themes

Institution	Key research centres, specialisms and assets
Emerging Infectious Diseases / Anti-Microbial Resistance (AMR)	
London School of Hygiene and Tropical Medicine (LSHTM)	The Malaria Centre was established in 1998 to facilitate interdisciplinary research. It brings together around 300 researchers, postgraduate students and support staff from all three faculties in LSHTM. It has a major international profile with members working in around 40 countries. In 2017, the Centre published 138 papers in 2017 and worked on more than 120 projects in over 45 countries. Established in 2012, the TB Centre focuses on reducing the global burden of TB disease through the development of effective interventions for the prevention, detection and treatment of tuberculosis infection and disease including: tracing TB transmission; Host-pathogen interactions; development and implementation of new diagnostics; clinical trials; epidemiology; and mathematical modelling The Antimicrobial Resistance Centre was launched in 2016 to foster connections between these scientific approaches and generate innovative approaches to science and policy. It brings together biological, social, mathematical, clinical and environmental sciences and the humanities to: - understand where, how and why AMR is a problem; and - develop, model and evaluate innovative solutions to reduce its threat

Institution	Key research centres, specialisms and assets
Royal Veterinary College (RVC)	RVC is one of the longest-established research bodies within the KQ. The RVC's work on infectious diseases and AMR is undertaken within and between three main research groups: • Ecosystems Health (ESH) – focusing on disease control and prevention • Host-Pathogen Interaction and Vaccinology (HPIV - understanding how pathogens interact with their hosts at molecular, cellular and whole animal levels • Safe and Sustainable Food (SSF) – examining the problems associated with different types of farming systems across livestock species RVC is expanding its activities in veterinary vaccines/antimicrobial resistance (e.g. plans have been submitted to create a £27 million Vaccinology and Cell Therapy Hub on the RVC's campus in Hertfordshire; the RVC is also lead institution in a £5 million project on infectious disease and AMR, funded by Research England under the Connecting Capabilities Fund). It is heavily engaged in supporting international development activities in low- to middle-income countries. Many of these activities are carried out in conjunction with other Colleges of the University of London – notably LSHTM and SOAS – under the auspices of the London International Development Centre (LIDC) and the Leverhulme Centre for Integrated Research in Agriculture and Health (LCIRAH).
University College London	UCL covers the full spectrum of research on AMR, spanning laboratory, clinical, epidemiological and behavioural studies. Within this context, the AMR Network brings together world-leading expertise in medical and public health research in the School of Life and Medical Sciences, together with disciplines such as engineering, chemistry and computer science. The Network also includes a collection of clinical resources and expertise available through associated hospitals (UCLH, GOSH, Royal Free). The UCL Partners network extends this clinical reach, and underpins strong academic collaborations with partner institutions with exceptional research strengths. Cross-disciplinary AMR research at UCL is organised around the following themes: • Understanding the threat: Developing a better understanding of bacterial pathogens, antibiotic resistance and host responses to infection. • Developing and testing therapies: Exploring the potential of existing and novel antimicrobial therapies. • Developing diagnostics and supporting stewardship: Exploiting new technologies to detect pathogens and characterise antibiotic resistance. • Tracking resistant organisms: Using genomic technologies to track transmission and pathogen evolution. • Changing behaviour and environment: Promoting better use of antibiotics and more effective infection control.
Francis Crick Institute	The Francis Crick Institute has a concentration of people and equipment/facilities for handling the agents responsible for infectious disease, and as such may be considered one of the UK's foremost research institutes in the field. The Crick's researchers are principally interested in understanding the molecular mechanisms of infection. There are 20 groups (circa 180 scientists, or 15% of the total scientific workforce at the Crick) working in this area, which covers the diseases that are most harmful to humans, i.e. TB, influenza, HIV and other retroviruses, and malaria. Key areas of activity are: • Understanding the replication/growth of major pathogens (viruses, parasites and bacteria), leading to novel targets for drug development. There is interest in specific pathogens, e.g. TB, and in understanding how drug resistance (AMR) develops, with the emphasis on molecular and cellular aspects – the underpinning biochemistry and structural biology. The Crick's researchers are also studying how host proteins interact with virus proteins, in order to trigger the immune system. • The Crick hosts the Worldwide Influenza Centre (WHO) which monitors the evolution of flu strains all over the world (143 centres in 113 countries) and receives samples of each new strain.

Musculoskeletal Pathology (MSK) associated with ageing

Royal Veterinary College (RVC)

Key research areas include:

- **Structure and Motion Laboratory:** This is part of the Comparative Physiology and Medicine Research Programme at the RVC. Group members investigate how animals move and how they interact with their physical environment, including how movement is controlled and the limits to performance.
- **Skeletal Biology Group:** Current areas of focus include osteoarthritis, bone pain, diabetes and bone, vascular calcification, tendon repair and regeneration, bone scaling and bio-mechanical skeletal interface. Experimental approaches established within skeletal biology include primary bone and vascular cell culture, molecular biology, microscopy, microCT and in vivo models of mechano-adaptive response and disease.
- **Tendon Biology Laboratory:** This has interests in: gait analysis, motion analysis, muscle mechanics, diagnostic imaging and lameness. Gait laboratory equipment includes force-plates, electromyography (EMG), and high-speed and motion-capture camera systems.
- **Comparative Neuromuscular Diseases Laboratory:** This investigates the aetiology, pathogenesis and treatment of neuromuscular diseases in animals (particularly veterinary patients) and humans.

University College London

Key research centres/groups include:

- **Centre for Rheumatology and Bloomsbury Rheumatology Unit** (Division of Medicine, Research Department of Inflammation): The centre undertakes clinical and basic research to increase our understanding of the cause of musculoskeletal diseases and improve their management.
- **Centre for Rheumatology & Connective Tissue Disease** (Division of Medicine, Research Department of Inflammation): Research focuses on critical mechanisms of disease pathogenesis including the cell and molecular players in inflammation, scarring and fibrosis. Focus includes degenerative joint disease.
- **Rheumatology Unit (not focused on ageing):** This group aims to improve the understanding of rheumatic diseases that occur in childhood and adolescence. Research is enabled by collaborations with the Adolescent and Adult Rheumatologists in the UCL department of medicine; and the rheumatology departments in Great Ormond Street and University College Hospitals
- **Aspire CREATE Centre for Rehabilitation Engineering and Assistive Technology:** this is a Joint research venture between the Aspire Charity, University College London and the Royal National Orthopaedic Hospital, Stanmore. The focus is on spinal injuries but also techniques that are applicable and transferable (e.g. in stroke, muscular dystrophy, amputation, etc.)
- **Centre for Materials Research:** This is concerned with replacing, restoring and regenerating musculoskeletal tissues through the interaction of innovated materials with surgical techniques, cells and tissues

Dementia

University College London

UCL has a major focus on all aspects of dementia – from prevention to care to cure. Key centres and/or research groups at (or linked to) UCL are listed below:

- **Research to reduce dementia prevalence:** UCL Centre for Behavioural Change; UCL Research Department of Primary Care and Population Health; UCL Mental health of older people department
- **Research to develop drugs that slow down or stop the disease:** UK Dementia Research Institute at UCL; UCL Institute of Neurology; Dementia Research Centre; Alzheimer's Research UK Drug Discovery Alliance; MRC Unit for Lifelong Health & Ageing; MRC Prion Unit; Leonard Wolfson Experimental Neurology Centre; Sainsbury Wellcome Centre; Max Planck UCL Centre for Computational Psychiatry and Ageing Research; UCL Department of Neuroscience, Physiology and Pharmacology
- **Research to develop new models of care, working with hospitals and primary care organisations:** UCL Research Department of Primary Care and Population Health; UCL Mental health of older people department; UCL Partners Dementia awareness training; START (STrategies for RelaTives); and Dementia Support Groups.

Source: Based on material provided to the KQ SIA

- 4.14 Over recent years, the major “new” player in relation to Life Sciences research inside the KQ has been **The Francis Crick Institute**. In terms of its science, this has been a nationally-significant venture. It is absolutely rooted in the KQ, both institutionally (with UCL and Wellcome among its founding partners) and locationally (noting that links within KQ and also out to Cambridge, Stevenage and continental Europe are already proving important). The Institute however is formally an independent charity. It is also large: over £650m has been invested to establish the Crick and its iconic building. The Crick opened in 2016 on a site which is adjacent to St Pancras station (to the east) and the British Library (to the south). It can accommodate 1,500 research scientists. Given its scale, processes of collaboration and commercialisation are still in their infancy, but examples are emerging, as summarised in Box 4-1 below.

Box 4-1: Case study of The Francis Crick Institute, and particularly processes of commercialisation and collaboration within and beyond the Knowledge Quarter

The Crick's focus is on basic research, but it is “*discovery research open to translation*”. The Crick has an in-house Translation team that works proactively with Crick research groups to identify and take forward ideas with potential for translation. This team runs an ‘*Idea to Innovation (i2i)*’ scheme, which holds a £500,000 Confidence in Concept award from the MRC to fund proof-of-concept work.

The most promising concepts can proceed a step further, and The Crick has spun out three companies thus far, all in cancer/immunology. One of these continues to be based in the KQ, but the other two have both moved out of London:

- **Gamma Delta Therapeutics** (now located at LBIC, within the Knowledge Quarter)
- **Achilles Therapeutics** (now based at Stevenage Bioscience Catalyst)
- **Artios Pharma** (now based at Babraham Research Campus, near Cambridge)

In addition, the Institute has entered into partnerships with GSK (since 2015) and AstraZeneca (since 2017) that, while focusing on discovery science, could lead to translational opportunities in future. The GSK-sponsored work is an important part of The Crick's overall research activity, whilst development of the collaborative relationship with AZ is at a much earlier stage.

Whilst the Crick's researchers have regular interactions with bodies outside the Institute, many collaborators can be found within the Crick's community of 1200 scientists. Others are within what is known as ‘The Greater Crick’, i.e. the three Crick partner institutions (UCL, Imperial College and King's College), with reciprocal appointments. This is a work in progress, trying to make the whole organisation more porous.

As The Crick's strategy focuses on excellence across the full breadth of biomedicine, there is likely to be a further diversification of The Crick's research activities over the next few years. Areas of focus are also informed by interactions with pharmaceutical companies – and it is difficult to predict in advance where drug discovery will lead. Interactions with big pharma are very important: pre-clinical work, validating the target / the mechanism, is key, such that companies can pick up issues early on, without spending \$1 billion on trials. The Crick is also talking with UK and overseas equipment manufacturers, notably those responsible for enabling technologies such as cryo-electron microscopes (cryo-EM) and other types of microscope, and Crick scientists are testing early versions of new equipment in their labs. This is a symbiotic relationship.

It is important for The Crick's researchers to be located in the KQ, giving access to research hospitals and clinicians (e.g. UCLH), and with excellent transport links – notably St Pancras with its Thameslink and Eurostar connections.

The latter is especially significant because there are approximately 400 non-UK European researchers working at The Crick. Some 40% of laboratory staff and 56% of postdocs hail from mainland Europe (The Crick has found it helpful to be able to recruit Ph.D. students from Europe as they tend to be high quality — most have Masters-level qualifications).

As a result, The Crick's researchers have numerous collaborations and joint projects with European partners, and win around £6 million per annum in European grants, mainly from the Horizon 2020 programme.

Source: Based on interviews with The Francis Crick Institute conducted as part of the SIA

Local science and innovation talent

- 4.15 The Life Sciences sector in the Knowledge Quarter draws on a vast labour market, not only commuters from across southern Britain but also skilled migrants from continental Europe (to which the KQ is connected by HS1/ Eurostar) and farther afield. This labour market is buoyed by the large body of students (circa 100,000 at any one time) that attend university within the KQ. Upon graduation these students form a huge talent pool from which the KQ's many businesses, universities, research institutes and hospitals are able to recruit the 'best of the best' — including highly skilled postgraduates, postdoctoral researchers and clinicians. Maintaining this supply of talent, including the most able students from overseas, is critical to the continued success of the KQ. To quote one example, the case study of The Francis Crick Institute (see Box 4-1) demonstrated just how dependent that organisation is on international recruits. In this context, there is much concern in relation to the possible consequences of the UK's departure from the EU in relation to international recruitment; and it will be important that visas can continue to be secured for new researchers and entrepreneurs to come and work in London.
- 4.16 In addition – and again facilitated by rail infrastructures – there is a two-way flow of highly qualified people between the Life Sciences sector in KQ and (in particular) the 'corridor' running through Stevenage to Cambridge. A business case study which – in part – alludes to this is provided below.

Box 4-2: Case study of Cell Medica

Cell Medica is a cellular immunotherapy company that is employing leading-edge technologies for the treatment of cancers.

The business was founded by Gregg Sando, just over a decade ago. After a successful career in investment banking in London and New York, he completed a Masters degree in immunology at Imperial College and then set up his new business in collaboration with clinicians and immunologists. The business was initially based at Gregg's home (in London). It now employs about 60 people in London, Zurich and Houston.

The business has developed several distinct technological platforms, all linked to oncology. These relate to Chimeric Antigen Receptors (CAR); genetically engineered T-Cell Receptors (TCR); and naturally occurring T-Cell platforms.

A major early collaboration was with Baylor College of Medicine in Houston – and it was largely through this link (which is on-going), and Cell Medica's Texas based investor, the Cancer Prevention Research Institute of Texas (CPRIT), that Cell Medica established a presence within the city. Today, about 20 of Cell Medica's staff are based in Houston, including some senior managers. Its Zurich operation is smaller – with about 10 staff – and it came about through the acquisition of a Swiss company (Delenex Therapeutics).

Cell Medica's activities in London are strongly focused in the Knowledge Quarter. The company's main offices are on Canal Side (a few minutes' walk from King's Cross station). It continues to use lab space at the Royal Free Hospital (which is to the north, but still in Camden). It has a major collaboration now with a research team based at UCL. This was signed in 2016 with the aim of accelerating the work of the UCL Institute of Immunity and Transplantation (IIT). In essence, the collaboration is structured such that UCL conducts preclinical and early clinical research whilst Cell Medica supports the product development and commercialization work. To this end, Cell Medica has an exclusive licence and option agreement with UCL Business (the technology commercialisation company of UCL) for cell therapies successfully brought to market.

Cell Medica is also collaborating with the Cell and Gene Therapy Catapult to establish a cell therapy manufacturing facility within the wider Cell Therapy Manufacturing Centre at Stevenage. Five members of staff from Cell Medica are based in Stevenage and additional support is provided from the London office. The consequence is that Cell Medica's UK footprint is therefore defined around three different locations within the Knowledge Quarter, plus Stevenage (where the focus is on the development of complex production processes).

In March 2017, Cell Medica closed a £60m Series C investment round with participation from Touchstone Innovations (formerly Imperial Innovations Businesses, and now part of IP Group plc), Invesco Perpetual and Woodford Investment Management. At present, the company remains pre-revenue.

In discussion, Cell Medica explained the value of its Knowledge Quarter location in part in terms of access to investors and in part in relation to an outstanding labour market (which means that the recruitment of very talented people is possible). Proximity to UCL is “*useful*” because they are “*in and out of each other’s offices a lot*”; and similarly, proximity to the Royal Free Hospital matters in terms of “*being one research effort*”. Beyond this though, while Cell Medica’s connections within the Knowledge Quarter are strong and growing, there is “*not yet*” a strong sense of a “*wider community*” in and around the Knowledge Quarter – although The Francis Crick Institute is no more than a few minutes’ walk away from Cell Medica’s Canal Side offices with acknowledged potential synergies.

Source: Based on an interview with Cell Medica conducted as part of the SIA

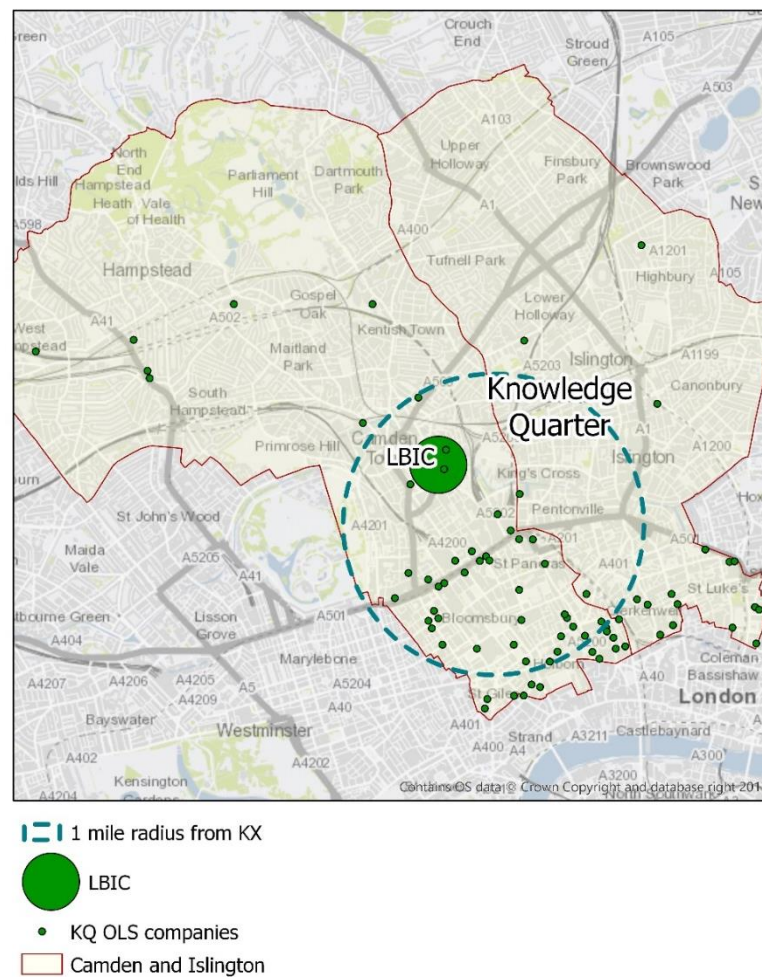
Local industrial strengths and capacities

- 4.17 Cell Medica is just one of the life sciences businesses based in the Knowledge Quarter. From the Office for Life Sciences database, it is possible to map Life Sciences businesses that have been identified in the KQ. Overall, this suggests that there are some 143 life sciences companies in Camden and Islington – a quarter of the London total.
- 4.18 Of these, the OLS database records 35 businesses as located at the London Bioscience Innovation Centre (LBIC): a quarter of the Camden and Islington total⁴⁰. However, this undercounts LBIC’s actual scale: taking into account firms with a ‘virtual’ presence, LBIC hosts 59 life science businesses⁴¹.
- 4.19 These businesses are mapped in the graphic below. Aside from LBIC, it is apparent that life sciences businesses are generally located in the southern part of Camden (i.e. along the Euston Road), very close to the principal centres of research identified above.

⁴⁰ Office for Life Sciences (2017), *Strength and Opportunity 2017: The landscape of the medical technology and biopharmaceutical sectors in the UK*, UK biomedical database

⁴¹ Information from LBIC

Figure 4-2: Map of life sciences businesses in the Knowledge Quarter



Source: Office of Life Sciences database. Mapped by SQW (Licence 100030994). Contains OS data © Crown copyright (and database right) 2018

4.20 Using different methods and sources – and on a very narrow definition – one estimate of the number of businesses and the number of jobs in life sciences within the Knowledge Quarter is provided in the table below.

Table 4-4: Life sciences: Businesses and jobs

	Businesses (local units)	Employee jobs	Employee jobs LQ (relative to GB, 2016)
Camden	75	600	0.6
Islington	20	175	0.3
Knowledge Quarter	95	750	0.4
Central London	240	2,250	0.3
London	625	5,000	0.3

Source: BRES (2016); UK Business Counts (2017). (Central London = Camden, City of London, Islington, Kensington and Chelsea, Lambeth, Southwark, Westminster). Note that numbers do not sum due to rounding issues

London Bioscience Innovation Centre

- 4.21 Within the KQ, London Bioscience Innovation Centre (LBIC) is an extremely important resource. It is hosted by RVC and was opened in 2001. Its history – and some of its current occupants – are described in Box 4-3.

Box 4-3: Case study of LBIC and some of the life science businesses/organisations within it

In 2000, the Royal Veterinary College (RVC) established London's first specialist incubator for the life sciences – London Bioscience Innovation Centre (LBIC).

LBIC supports over 60 companies ranging from entrepreneurial start-ups and university spin-outs to major corporations. Approximately one quarter of LBIC's clients originate from overseas – with these companies using LBIC as a springboard to UK and European markets. LBIC's mission is to accelerate the innovation and growth capacity of its client companies and to reduce the risk to innovation performance. LBIC's facilities and services are designed to encourage innovation in biomedical and bio-veterinary research and its close proximity to the RVC provides clients with access to specialist experimental facilities, equipment and academic expertise in integrative in-vivo animal physiology and pathology.

LBIC clients actively collaborate with RVC academics, encouraged by LBIC with matched funding drawn from the RVC under the Concept Development Partnership scheme with the aim of incentivising collaborative relationships between industry and academia.

LBIC's direct access to businesses allows the RVC to deliver advanced BSc/BVetMed curricula, Postgraduate courses and professional CPD, bringing LBIC client companies into direct contact with undergraduate and postgraduate students. LBIC has further supported the educational experience and employability skills of students and postgraduates via internships, commercial awareness training and mentoring for national entrepreneurship competitions.

In recent years LBIC has been operating at or close to capacity (within about 28,000 sq ft of lettable space). Current industry demand, together with the proximity to The Francis Crick Institute would justify significant expansion which would help achieve the economies of scale afforded to other larger incubation/innovation facilities. LBIC has been exploring opportunities to expand its operations offsite. However, the potential cost of doing this is prohibitive.

Perspectives from tenants

Three LBIC tenants provided information to the KQ SIA. Of these, two were commercial businesses and one was a university-related organisation which sells products/services. All three had moved to LBIC since 2010. They gave varying reasons for choosing to locate at LBIC:

- one business chose LBIC because of its location – staff members can travel there from across the UK; it is close to investors in the City as well as universities and hospitals; and it is an attractive area
- another business chose LBIC because it wanted to be in a biomedical environment to benefit its research in healthcare fields and have open the possibility of collaboration
- the university-related organisation chose LBIC because it was “the only place in London with the right facilities”.

Collaboration was important to all three of the LBIC tenants. One business stated that its most significant collaboration was with London-based investors due to needing funds to bring its product to the market. In order to secure investment, the business holds frequent meetings in London and shows its lab and technology to potential investors. Another business stated that its most important collaborators were “other LBIC tenants”. The university-related organisation stated that its most important collaborator was the Royal Veterinary College (RVC) and a location at LBIC facilitated this link.

All three of the LBIC tenants had deepened relationships with other bodies inside KQ since moving to LBIC (e.g. hospitals, universities, LBIC tenants) and all were expecting to continue to develop important relationships with some of these in the future (e.g. local hospitals, The Francis Crick Institute).

All three tenants were planning future growth and, if their plans are realised, all expect to see net recruitment. Of the three tenants, one is expecting to remain at LBIC whilst the other two are expecting to move some of their activities elsewhere by 2021. In one case, this meant partial relocation out of London (into the Greater South East).

Source: Based on information provided by LBIC; and also a survey of LBIC tenants, conducted as part of the SIA, spring 2018

- 4.22 LBIC is a seriously important resource in relation to the commercialisation of Life Sciences within KQ. However, it is full, with a waiting list, and a major issue facing tenants surrounds the dearth of “next steps” accommodation. The issues are exemplified by one small company, Jupiter Diagnostics. The issues it is facing are summarised below.

Box 4-4: Case study of Jupiter Diagnostics

Jupiter Diagnostics is a medical technology company which has developed a portable reader providing rapid and accurate blood tests at the point of care. Developed initially for the gynaecology market, it potentially saves time and it ought to benefit clinicians and patients alike.

The technologies underpinning Jupiter’s product derived from two early stage businesses that both “*almost got there*”. They were brought together in 2015 by Chris Ball, who had prior experience of biotech start-ups in the UK and in Boston. The three Jupiter founders lived in Kent, Cheshire and Northamptonshire. London was the easiest location for all three.

Through a telephone call, space was found at LBIC. Jupiter was able to move into a fitted out lab of 600 sq ft with a 12 month lease, break clauses, and rent of just over £60 per sq ft. This combination created a “fantastic resource” and it has been a very important part of the company’s growth narrative. Jupiter – like many other medtech start-ups – is pre-revenue and it has had a “hand to mouth” existence. The flexibility of provision at LBIC has therefore been invaluable.

Since being at LBIC, Jupiter has worked closely with several London hospitals – both NHS hospitals and private IVF clinics. The proximity of clinicians has been crucial. There has also been a dialogue with academics from UCL, which has been useful. Another important factor has been access to the investment community, both within London but also in Cambridge and Oxford. Finally, LBIC has been a good location from which to attract talented staff (including non-UK nationals); and to date, recruitment has not been too difficult.

Jupiter moved into LBIC with four members of staff. It doubled this number within two years and by the end of 2018, it should double again. However, it is now running out of space. Other provision in the area around King’s Cross is very expensive, partly because of business rates.

In planning for its own growth, Jupiter has been forced to look further afield – this has included QMC/Whitechapel, Harlow, Chesterford Research Park, Stevenage, and Discovery Park (East Kent). Jupiter is likely to relocate part of its operation to Discovery Park. The reasons for this relate to cost, the existing facilities and the fact that staff with production/manufacturing skills ought to be available locally. However, it intends to retain a foothold at LBIC – because of the importance of clinical partners, investors and customers in London.

Jupiter considers that the life science community around LBIC behaves like a cluster to some extent. But compared to what it considers to be the best life science clusters in the UK (Cambridge) and internationally (Kendall Square in Boston), there are some gaps. Currently, it considers the strength of informal networking to be weaker than elsewhere, particularly in terms of the density and intensity of links between larger and smaller companies.

Source: Based on an interview with Jupiter Diagnostics conducted as part of the SIA

Spin-out businesses

- 4.23 Some of the life sciences businesses located in the Knowledge Quarter are spin-outs from the area’s anchor institutions. The most prolific in this context has been UCL. Data were sourced from UCL’s tech transfer office (UCL Business (UCLB)) in April 2018 for the years from 2010/11 to 2017/18. Over this period, 49 spin-outs were identified of which 28 were identified as from within the life sciences. Some of these are both based within the Knowledge Quarter and at the core of the themes identified within the SIA. One example – BrainMiner (which actually spans the dementias sub-theme within life sciences and machine learning) – is profiled in Box 4-5 below.

Box 4-5: Case study of BrainMiner

BrainMiner Ltd was established in 2015 by Professor Sebastien Ourselin, Dr M. Jorge Cardoso, and Dr Marc Modat working in conjunction with UCL Business PLC to capitalize on research and translational collaborations between UCL's Department of Medical Physics, Department of Neuroradiology (National Hospital for Neurology and Neurosurgery) and the Dementia Research Centre (UCL Institute of Neurology).

BrainMiner is seeking to help the NHS meet its 2020 target of a standard diagnosis timeframe of six weeks post referral for dementia and Alzheimer's disease, by assisting radiologists and neurologists in the diagnosis process. This is achieved through the use of an innovative software infrastructure that automatically and intelligently analyses magnetic resonance imaging (MRI) scans. Current output from MRI scans are reliant on a qualitative assessment by a radiologist, who must visually analyse an MRI image for signs of structural or volume change to the brain.

DIADEM – BrainMiner's 1st product – uses a patented machine learning algorithm that identifies 150 separate regions of the brain. It then compares each region to its expected size, based on the patient's age, intracranial volume and other factors. The software provides accurate volumetric information around key brain structures in a timely and cost-effective manner, allowing for better diagnosis.

The early development of BrainMiner was supported through over £1m funding from SBRI which enabled the translation of the DIADEM product from a university research tool into a CE marked product and which secured initial adoption within a clinical setting in 2018. This is providing the foundations for the company to raise a Series A round of investment over the summer of 2018. This will support the clinical roll-out of DIADEM in the UK and overseas markets together with the development of further intelligent image analysis tools for use in the management of Stroke and Multiple Sclerosis.

Currently, BrainMiner is based in offices located very close to the UCL campus and employs five staff, with more to be hired upon completion of the investment round. This proximity to major research hospitals (i.e. UCH, Royal Free Hospital and the National Hospital for Neurology and Neurosurgery) is vital for the company and UCL to accelerate med-tech translation and thus deliver substantive patient benefit from UCL's research base. However, the absence of incubation space in the area around UCL that is flexible and affordable coupled with technical staff recruitment challenges (arising for example from restrictions on Tier 2 visas) means that healthcare AI companies such as BrainMiner may have to move away from London in order to progress their commercialisation journey.

Source: Based on a review of website material and a discussion with UCLB

National and international engagement

- 4.24 The Knowledge Quarter is within the capital city at the heart of the national transport infrastructure and it hosts many organisations/institutions with a national remit. For those reasons alone, there is a great deal of national engagement. The excellence of Life Sciences research within KQ accentuates this process while the dearth of provision for early stage life sciences businesses (particularly at the point of scale up) forces it.
- 4.25 As one might expect from an area with an extraordinary density of Life Science assets, the KQ has a wealth of research connections and collaborations with organisations elsewhere in the UK and internationally. On the whole, these connections have developed organically over time rather than being 'engineered'. They are far too numerous to detail here but major UK scientific collaborators by sub-theme can be summarised as follows:
- **Infectious Diseases:** universities and university hospitals in Liverpool (Liverpool School of Tropical Medicine, University of Liverpool), University of Oxford and University of Edinburgh (Roslin)
 - **Musculoskeletal Pathology:** University of Birmingham, University of Oxford
 - **Dementias:** Newcastle University, University of Oxford

- 4.26 These collaborations represent 'best with best' alliances, in many cases involving clinicians as well as academic staff. They highlight the fact that the reach of the KQ extends well beyond the Golden Triangle of London/ Oxford/ Cambridge — albeit the University of Oxford is a key collaborator in all three sub-themes.
- 4.27 Internationally, academic institutions in the KQ have developed scientific collaborations with top-ranking universities, research institutes and businesses in mainland Europe, North America, Asia and Australasia, as well as myriad smaller players across the globe. There is no single database that enables the mapping of these connections, albeit statistics for international co-authorship of journal papers, and researcher mobility offer a clue as to the geographical spread and richness of these relationships. For example, across all subject areas, UCL's academics produced 124,161 research papers between 2007 and 2016 — the highest number of any UK university — of which 39,221 (31.6%) were co-authored with researchers from other European countries. Similarly, in terms of Life Science publications co-authored with industry, 88% of LSHTM's output was with organisations based overseas — the highest of any UK higher education institution. Two-fifths of these papers were co-authored with businesses based in other European countries. The LSHTM also tops the UK league table for data on international mobility of researchers between universities and industry (e.g. diagnostics, medical devices), with 60% of its total number of staff exchanges with industry being with companies outside the UK. Of these exchanges, nearly one-third (30%) were with industry in Europe.
- 4.28 On the business side, corporates such as US pharmaceuticals giant MSD (which has recently established a base at LBIC) have well-established global networks in science. These have been developed through the MSD Innovation Network (MINT), in which the company collaborates with leading scientists worldwide in the antimicrobial field to investigate novel therapeutic targets, evaluate new pathways for drug targeting and develop novel tools and technologies. Since 2012, MSD has funded more than 40 such collaborations through MINT, including ongoing work with scientists at Harvard, Yale and Princeton universities. This network will provide an 'instant' set of international collaborators for staff based at MSD's UK Discovery Centre, due to be established in the KQ by 2020. Many other examples of networking by businesses in the KQ could be quoted here. For instance, Benevolent AI — a company that leads the field internationally in AI-enabled drug development — is working with the Sheffield Institute of Translational Neuroscience (SITraN), part of the University of Sheffield, on finding treatments for ALS (motor neurone disease). Benevolent, which was formed in 2013, has recently established offices in Belgium and New York City, as well as acquiring laboratories just outside Cambridge (Babraham Research Campus) for its subsidiary, BenevolentBio. This young company is a major success story for the KQ, drawing international attention for work that aims to drastically reduce the time it takes for drug candidates to enter clinical testing, and deliver significantly higher success rates in treating or curing disease.
- 4.29 Small- to medium-sized companies within the KQ also see the need for extensive national and international engagement in order to secure investment, e.g. from 'patient capital'. A good example of this is the set of seven Life Science companies in the investment portfolio of Syncona, a UK investment company valued at £850 million. These companies include: the UCL start-up Autolus, a company that specialises in engineered T-cell therapies for cancer, and which is now based at White City (Autolus secured circa £90 million total investment from Syncona, commencing in 2014, and reached \$150 million in its June 2018 IPO); Freeline Therapeutics,

a spin-out from UCL Royal Free Hospital that is developing gene therapies for blood disorders (founded in 2015 with a £25 million investment from Syncona); and Achilles Therapeutics, another UCL spin-out, that is developing immunotherapies for late-stage cancer (£13.2 million investment from Syncona in 2016). The latter two companies have recently moved out of the KQ, to join other cell and gene therapy companies at Stevenage Bioscience Catalyst (see Box 4-6 below).

Box 4-6: Case study of growing links from KQ into Hertfordshire through Stevenage Bioscience Catalyst

The Stevenage Bioscience Catalyst (SBC) is a Life Sciences incubator which was established in 2012 with funding from the Department for Business Innovation and Skills, GlaxoSmithKline (GSK), the Wellcome Trust and Innovate UK. It is situated on GSK's campus in Hertfordshire, and was set up with the intention of encouraging interactions between entrepreneurs in the incubator and scientists on the GSK R&D site – while respecting the entrepreneurs' freedom to interact with any commercial or academic partner. SBC's role is to support high-growth SMEs, by providing access to expertise, specialist equipment and facilities that would otherwise be beyond the reach of small companies. It houses 52 businesses, including two spin-outs from UCL and one from The Crick. The University of Cambridge also has offices at the SBC, mainly in order to pursue early-stage translational projects with scientists at GSK.

In the five years since its foundation, SBC has seen a growing demand for its space – and especially laboratory space – from companies wishing to move out of London or Cambridge (but mainly Cambridge), whilst remaining within a comfortable commuting distance from each of these cities. The demand is such that currently, SBC is in the process of converting offices on its upper floor into laboratories, with the space already let to a new tenant. This will reduce the number of tenants from 52 to 44.

The 'magnet' for tenants was originally GSK (only), but more recently it has become GSK plus the presence at Stevenage of the Cell & Gene Therapy Catapult (CGTC), with its new £70-million Stem Cell Manufacturing Centre. The CGTC provides a vital link to clinicians at Guy's Hospital in London, which is home to more than 120 cell and gene therapy experts, plus state-of-the-art development and viral vector laboratories. The CGTC's 7200 sq m Manufacturing Centre, due to open in 2018, will likely become a major draw for biopharmaceutical companies and SMEs working in the 'cell and gene' area.

Would-be tenants must pass strict criteria for entry to SBC; notably they must be generating their own intellectual property, be in receipt of funding/investment and be in a position to be capable of benefiting from the support offered by SBC (e.g. networking, access to investors, access to translational funding such as that provided through Apollo Therapeutics (<https://apollotherapeutics.com/>) – a collaboration between GSK, Johnson & Johnson Innovation, AstraZeneca and the technology transfer offices of Imperial College, UCL and the University of Cambridge). Starting in 2017, SBC tenants have been given the opportunity to mentor staff from GSK – an 'talent development' initiative that has proved to be tremendously popular with the mentees.

A key feature of SBC since its inception has been its encouragement of an Open Innovation model for R&D (see: http://www.stevenagecatalyst.com/openinnovation_at_sbc/). A key entry criterion is for tenants to agree to periodic reviews of their 'openness', as expressed through engagement with other businesses at SBC, investors and SBC's Board. Tenants have an obligation to make presentations to the SBC Board on a regular basis, and SBC staff track the degree of engagement shown by each company, e.g. their attendance at tenant networking events and investment meetings. From the outset, certain metrics were put in place to monitor the success of the SBC's 'ecosystem'. The effect of these metrics has been studied since 2012 by academics from Lancaster University's Management School. They are interested in understanding whether the SBC Board's aim of cultivating a sense of accountability amongst SBC tenants – towards the Board and other tenants – encourages greater openness, leading to high performance and sustainable businesses (see:

http://www.stevenagecatalyst.com/openinnovation_at_sbc/newpage/).

Source: Based on discussions with SBC conducted as part of the SIA

Conclusions and future potential

- 4.35 The KQ has substantial assets in relation to the life sciences in general and particularly the three specialisms that have defined the core of the SIA's life sciences theme. Over the last decade, the strength of its science base has increased further with the establishment of The Francis Crick Institute which is a major national resource. Arguably its full impact – in terms of commercialisation – has yet to be seen.
- 4.36 However, the SIA also identified three major constraints in relation to life sciences, all of them property-related. These are:
- **low availability and high cost of appropriate commercial sites and premises.** The US pharmaceuticals giant Merck, Sharp & Dohme (MSD) announced in November 2017 that it intends to site its new UK Discovery Centre in the KQ. By 2020, this Centre is expected to house 950 staff including 150 researchers. Thus far, MSD has been unable to find suitable premises.
 - **a dearth of innovation space, especially wet-laboratory space for Life Sciences start-ups and small businesses.** As explained, LBIC on Royal College Street is still the only large innovation facility in the KQ. Since opening it has run at, or close to, full capacity, with a waiting list of potential tenants.
 - **a lack of suitable move-on space** in the KQ for companies wishing to expand their operations and/or take on additional staff.
- 4.37 To some extent, these constraints – particularly the third – need to be addressed outside the immediate geography of KQ. But solutions ought to be found for the first and second if the full potential of an outstanding scientific asset base is to be realised.



5. Theme 2: Cultural, scientific and heritage collections

Chapter Summary:

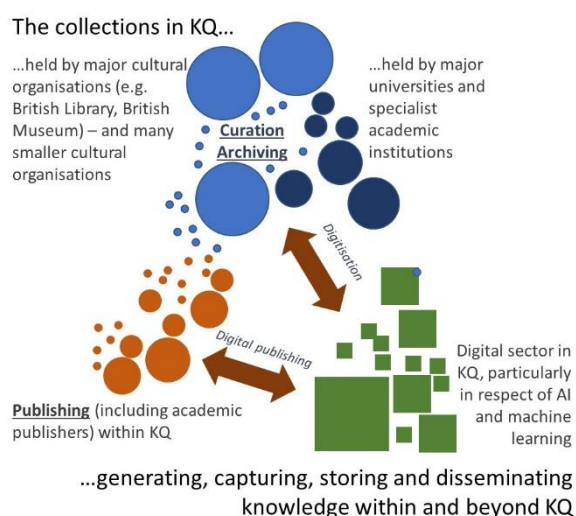
The KQ's cultural, scientific and heritage collections are being transformed by digital technology. New ways of understanding objects, new avenues to engage the public, and the much greater 'reach' enabled by digital are opening up new possibilities. In their digitised form, collections are becoming one part of the creative content-generating industries, a key industrial sector for the UK.

The KQ is well-placed to contribute to this. It contains many internationally significant collections, as well as a host of smaller specialist ones; a notable publishing cluster; and universities producing graduates trained in the disciplines required. To date, these groups have not come together in a systematic way to share their distinct but related sets of expertise, and so have not harnessed the full potential of these new technologies. Various factors explain this, such as the expense of digital curation and the shortage of suitably-skilled staff. More fundamentally, many collections (which are often publicly-funded) see their role as disseminators of knowledge as much as producers of it, and see digitisation as enabling that dissemination to be as wide as possible. Digital content of collections is better seen as a 'raw material' that others can use to develop new ideas, products and services (including commercial ones) rather than leading directly to commercial products.

Scope and links to our hypotheses

- 5.1 The Industrial Strategy White Paper acknowledges the significance of the creative industries. The shift to digital, where much of the growth in creative markets now takes place, is generating vast amounts of digital content which in turn is creating both opportunities and imperatives for innovation. **Cultural, scientific and heritage collections** comprise an important set of actors in this overall context. *The possibilities being opened up by the digitising of content offer collections new ways to reach audiences, to encourage learning, to collaborate, and to help commercial companies create new products and services while retaining some of that commercial benefit to support their own activities.* Many collections have already started down this path through their **digital publishing, archiving and curating** activities.
- 5.2 However, these disruptive opportunities also bring challenges. These include securing the funding and skills required to accelerate digitisation processes; the difficulties in managing complex copyright environments; and the need to balance objectives that may be conflicting (e.g. between commercial and publicly-funded business models). In this climate, particular opportunities for collections may arise from collaboration with other actors in the digital space.
- 5.3 The blending of content, data science and technology platforms in the pursuit of integrated, end-to-end digital experiences demands a more connected ecosystem. As illustrated in the graphic below, KQ is home to major concentrations of activity in the domains that make up this ecosystem: the collections held by the area's great cultural and educational institutions; a cluster of world-leading publishing firms, across both commercial and scholarly publishing; and a complement of tech firms (described in more detail in the chapter that follows this one).

Figure 5-1: The role of collections within a digital knowledge ecosystem



- 5.4 This chapter explores the potential of this part of KQ's wider innovation ecosystem, particularly through the lens of the largest collections and archives in the Knowledge Quarter. It focuses on the British Library, the British Museum, and the collections of UCL and the Wellcome Trust. However, there are many other collections of national (and often international) significance in the KQ area, some with particular specialisms, from the Charles Dickens Museum to the Cartoon Museum. This mix of small and large organisations is at the heart of the KQ's response to the possibilities surrounding digitisation.

National and international trends and size of global markets

- 5.5 Stakeholders involved in the SIA identified overarching trends and drivers which are transforming the publishing, curation and archiving activities of the major collections. Many of these reflect the consequences of digital and data science advances. From traditional publishing and media companies to online content developers and cultural content creators, organisations are adjusting their business models to handle multimedia content and harness new technologies, while in many cases still creating (or curating) physical products and experiences. Within this overarching context:

- **The amount of digital material that is being created, collected and preserved is rising significantly.** The British Library, for instance added 80 terabytes of digital content in 2016/17 alone,⁴² and now holds several petabytes⁴³ worth of data. The Wellcome Collections extend to 40 terabytes (36 million images or 220,000 items, 1,000 video and sound files) with around 4.5 million images being added each year⁴⁴. Such organisations have invested substantially in digitising and cataloguing analogue sources and are now gathering born-digital content at scale including: websites, electronic personal archives, data related to historic buildings and environment, data related to entire digital collections, geographic and provenance data, archaeological

⁴² From British Library's annual report 2016-17 <https://www.bl.uk/aboutus/annrep/2016-17/Annual%20Report%202016-2017.pdf> – Consists of 70 TB acquired through a web crawl, plus other digital ingest and digitisation of historic content

⁴³ A terabyte is 1 trillion bytes; a petabyte is 1,000 terabytes

⁴⁴ Data provided by Wellcome Collections to the KQ SIA, June 2018

data, ecological and biodiversity data, data related to specific communities and audience-related data.

- **AI and machine learning are starting to help the industry to manage and develop new ways of consuming digital content, but for its use to be adopted fully, much needs to be done to protect privacy and understand data bias.** New models of co-creation and user-driven content creation need to be nurtured, but organisations across this sector have yet to deal adequately with the difficulties of verifying content (encapsulated in ‘fake news’ problems).
- **Organisations need to learn to handle heterogeneous and multi-format data.** There has been very little collaborative work done to date to systematically move forward the sector’s knowledge of how to deal with cultural and natural heritage data in such a way that they can be linked, analysed, processed and understood. There is also a need to consider underlying standards and sustainability in ways that are appropriate for collections, as well as addressing the issue of obsolescence in digital formats.
- **IP and rights management, including copyright, are changing in a digital world and in the context of Brexit.** Publishing is dependent on a complex system of IP and rights management closely linked to EU legislation: the industry is keen to ensure that high-level intellectual property laws, including copyright, are maintained in the process of leaving the EU. At the same time, digital innovation is challenging the existing legal environment. As collections and publishing become data-intensive, it will be crucial to understand who controls data infrastructures, and how the roles and rights of creators, organisations and consumers are changing, especially in areas where digital technologies are enabling greater sharing, collaboration, use and reuse of content and data.
- **Immersive technologies are creating new opportunities and imperatives.** Virtual and augmented reality (VR and AR) are rapidly growing new forms of entertainment – the *Culture is Digital* report estimates such technologies could generate £100bn of sales worldwide by 2020⁴⁵. In the UK there are currently estimated to be 1,000 immersive specialist companies, with sales of £660m⁴⁶. The government has set a target of doubling Britain’s share of the global creative immersive content market by 2025⁴⁷. Such firms will need content and access to audiences. VR and AR will define new ways to experience digitised objects (rather than just text-based material), and in so doing offer new approaches for accessing and enjoying collections.
- **‘Open access’ (OA) publishing is becoming much more important.** Open access represents a way of engaging audiences with open cultural and heritage resources and is seen by authors as an effective way of reaching wider audiences, something that is especially important for medical and scientific literature. Springer Nature found that its OA books receive seven times more downloads on average than its non-OA books, and were 50% more likely to be cited⁴⁸. There is an increasing trend for

⁴⁵ DCMS (2018), *Culture is Digital*, p13

⁴⁶ Immerse UK (2018) *Immersive Economy in the UK*

⁴⁷ *Ibid.* p4

⁴⁸ Springer Nature (2018) *The OA effect: How does Open Access affect the usage of scholarly books?*

funderson to insist scholarly work is made openly available, and the next Research Excellence Framework will further extend the OA requirements on submitted work.

Box 5-1: Feedback from the “Collections workshop” in relation to wider trends and drivers

Attendees whose organisations hold collections reported that they were used mostly by researchers and students, as well as universities, other libraries and galleries. The majority of collection holders themselves use (or collaborate with) other collections in the KQ area. The British Library and Wellcome were the two most frequently mentioned, with the British Museum also being important. Some of these collaborations have led to commercial products: Springer Nature has developed Palgrave Pivots with Wellcome (among others) – it enables authors to publish pieces of between 25,000 and 50,000 words (i.e. longer than a journal article but shorter than a monograph) on greatly reduced publication times, through the use of flexible digital publishing processes.

To date, most attendees reported that the Knowledge Quarter partnership’s network, while relatively new, is providing opportunities to ‘start conversations’, through networking and its events programme. The interdisciplinary nature of the KQ network is valued for providing wider opportunities.

Key points from the discussion phase of the workshop:

- **Digital innovation is at its best when it interacts with and enhances existing physical services.** Physical infrastructure need not be envisaged as competing with digital innovation.
- **Digital technology is often about enhancing visibility and access.** It enables a larger and more diverse audience to enjoy and learn from collections currently deemed niche or specialist. However, digital cataloguing/archiving remains expensive (and is difficult to fund) and requires specific knowledge/skills.
- **Most digitised collections are used primarily for public engagement and appreciation; they are not necessarily used for proactive work with SMEs.** This means, though, that cultural institutions have expertise in engagement that sciences may lack – one example cited was Poet in the City’s work with Bio Nano Consulting to communicate the results of a complicated piece of physics research. More generally, there are big scientific problems which require the public to be involved if they are to be addressed – there is a need to close the gap between research and the public.
- **The KQ has the ability to take the initiative in both stating the strengths of, and providing a model for, sustainable digital innovation through open-source and publicly owned digital platforms.** There are opportunities to collaborate within the KQ, but they tend to be driven by serendipity rather than being marshalled or structured. However, a lot of KQ organisations have priorities in common – which may provide scope for joint projects – and the parity implicit in membership of the KQ partnership puts large and small organisations on an equal footing (at least in theory).
- **Many of the institutions, either because of their size or particular specialisms, have national or even international reach.** These wide-ranging, established networks provide important dissemination and engagement opportunities. However, the KQ area itself has been transformed in recent years, especially around King’s Cross – one big challenge for institutions is to connect with (new) local business and communities. There are very few local SMEs within the KQ partnership’s membership at present.

Source: SIA Collections Workshop

Local science and innovation assets

- 5.6 Collections within KQ are many and varied, ranging across national collections such as the British Museum and the British Library; the activities of associations or membership organisations (e.g. the collections of the Royal College of Physicians, the Royal College of General Practitioners, and IOM3); historical figures (e.g. the Charles Dickens Museum and the Marx Memorial Library); social movements (e.g. humanism at Conway Hall), religious groups (the Jewish Museum, Dr Williams’ Library); and industrial/commercial activity (such as the London Canal Museum). There are also many specialist collections associated with the KQ’s universities.

- 5.7 The table below summarises the size and variety of the major (physical and/or digital) collections within KQ.

Table 5-1: Assets linked to major collections and archives in the Knowledge Quarter

Institution	Key assets
National Collections	
British Museum	BM is a public institution dedicated to human history, arts and culture, holding approximately 8 million physical objects. BM attracted 6.4 million visitors in 2016. For ten years the BM has been the UK's most popular visitor attraction. In the UK, 9 million people saw BM objects outside London in 2016/17. The BM loaned 3,000 objects to 156 venues. As of 31st March 2017, Collections Online (the version of the BM's Merlin database that is publicly available on the internet) included 2.32 million records and 1.53 million images. Around 58,000 new records were added to the Merlin database in the period April 2016-March 2017. Collection Online objects numbered 4,131,454 at 31/03/2017, an increase of 104,328 objects over the previous year. This is one of the largest online collections of any museum in the world. The British Museum has benefited from advanced digitisation technologies such as in partnering with Google to digitise the fragile collections photographs and casts of some of the most ancient Mayan objects and sites collected by the British explorer Alfred Maudslay. Digital projects are also used to enhance user experience such as the Google Street View offering a detailed tour of all the galleries. Equally, in the Museum's learning activities Samsung Digital Centre provides free activities and workshops using the latest Samsung digital equipment, enabling children to bring the world's history and cultures to life through advanced technology.
British Library	BL holds 200m physical items in multiple formats (books, manuscripts, sound, video, newspapers, data, etc.); 2bn pages of UK web content; 6.5m audio items; 60 million patents; 260,000 journal titles Some 410,000 visitors to the reading room and 1.5m visitors overall per annum, 20 million online visits per annum Annual growth amounts to 3 million new items (12 kilometres of shelving space) – stored mostly in Yorkshire (the Boston Spa facility stores 70% of the Library's collections) – and 80 terabytes of material The Library delivers the UK Web Archive and, in 2016, conducted the fourth UK domain web crawl, harvesting some 70 terabytes of content. This is estimated at approximately 2 billion web assets (including web pages, images, videos and documents) and some 12m websites BL's extensive digitisation programmes include the major partnerships with DC Thomson/ Find My Past which has to date digitised over 28m newspaper pages; Google, which has to date digitised over 500,000 books; and the Qatar Foundation, which has created the Qatar Digital Library, a free resource aiming to transform the study of Gulf history and improve understanding of the Islamic world, Arabic cultural heritage and the modern history of the Gulf. In December 2016, the BL agreed a new data strategy, built on the vision that data will be as integrated into its services as text is today British Library Labs is an initiative funded by the Andrew W. Mellon Foundation, that has (since 2013) been inviting researchers, educators, developers and artists from around the world to work with the BL to address important research questions or undertake creative endeavours by using the Library's digital content and data in exciting and innovative ways. As part of the British Library's aim to open its data to wider use, a selection of digital datasets is available for download at data.bl.uk. The Labs team also provides technical support for researchers and businesses who wish to engage with these collections. The projects to date include the use of semi-automated image classification and machine learning techniques to add meaningful tags to images and create thematic collections, and a large-scale comparison of world music corpora with computational tools.
Wellcome Collections and Library	Within the Wellcome Collections, the "Core Collections" have several main elements: • Visual and material culture comprises: ➢ Sir Henry Wellcome's Museum Collection, a closed collection of mainly three-dimensional objects. The most significant part of this collection, comprising over 117,000 historic items relating to medical history and the history of science more generally, has been on long term loan to the Science Museum since 1976. Other smaller elements of the collection, including a group of Egyptian stelae and a collection of classical statuary, are on long-term loan at other institutions. ➢ an estimated 250,000 prints, paintings, drawings and photographs, and a small number of other artistic objects, dating from the C14th to the present day, which are directly managed by Wellcome Collection. • Printed and published rare materials include significant holdings of rare and early printed books, ephemera and pamphlets. In addition to around 70,000 monographs

Institution	Key assets
	(including over 600 pre-1501 books, and over 5,000 16th-century books), the collection includes more than 900 pamphlets and 700 items of ephemera. • Archives and manuscripts include unpublished material, drafts, notes, letters and photographs in both analogue and born-digital formats, including over 3,000 moving image and sound recordings. There are over 800 collections of personal papers, organisational archives, image and audio-visual collections and around 21,000 manuscripts in over 50 different languages, dating from antiquity to the present day. In addition to material collected from outside, Wellcome holds the corporate archives of the Wellcome Trust, Wellcome Foundation Ltd., and other predecessor and related organisations and associated individuals. • The Wellcome Library has major holdings of scientific books, journals and objects, especially relating to medicine. It has several distinct collections, covering subjects including the history of medicine; paintings, prints and drawings; rare books, and moving image and sound. Wellcome Trust also supports other organisations carrying out digitisation activities. It has, for example, funded many projects at London Metropolitan Archives (based in the Knowledge Quarter) for the cataloguing, conservation, digitisation and engagement with sources for the study of the history of medicine through its Research Resources in Medical History scheme. Current projects relate to the Foundling Hospital's medical records and the Tavistock and Portman NHS Foundation Trust (in Camden).
University Collections and libraries	
UCL Collections and Library	These are organised around a series of Museums and Collections: • Grant Museum: The only remaining university zoological museum in London, housing around 67,000 specimens • Petrie Museum: One of the world's most significant collections of Egyptian and Sudanese archaeology, housing an estimated 80,000 objects • UCL Art Museum: More than 10,000 prints, drawings, sculptures, paintings, and media works dating from the 1490s to the present day • Institute of Archaeology Collections: The collections include prehistoric ceramics and stone artefacts, and collections of Classical Greek and Roman ceramics • Ethnography Collections: The Ethnography Collections hold a huge variety of objects exemplifying material culture, textiles and artefacts from all over the world. • UCL Special Collections is one of the foremost university collections of manuscripts, archives and rare books in the UK. It includes collections of medieval manuscripts and early printed books as well as significant holdings of 18th century works, and important 19th and 20th century collections of personal papers, archival material, and literature, covering a vast range of subject areas, notably Latin American archives, Jewish collections and the George Orwell Archive. • Other collections include the materials library, the geology collection, the science collections and the (Sir Francis) Galton collection. • UCL Library Services consist of 18 libraries, covering a wide range of specialist subjects ranging from bio-medicine and science to arts, architecture and archaeology. UCL is a leading university in promoting innovation in Open Science, including starting UCL Press, the UK's first completely open access university press.
SOAS Library	SOAS Library is one of the world's most important academic libraries for the study of Asia, Africa and the Middle East. The Library attracts scholars from all over the world to consult its holdings and further their research. The Library houses over 1.3 million volumes at the SOAS campus at Russell Square in central London, together with a major collection of archives, manuscripts, rare books and special collections, an expanding Digital Library and a growing network of electronic resources. In 2011 SOAS Library was designated by HEFCE as one of only five National Research Libraries, based in the UK universities, and as such receives direct funding to support UK higher education research in Asian, African and Middle Eastern studies.
University of London – Senate House and School of Advanced Study Libraries	Senate House Library is the central Library of the University of London and the School of Advanced Study. It has a rich history at the heart of the University, and London's student and research community. In addition, the School of Advanced Study's institutes have internationally-renowned research libraries. Collections comprise in excess of 1.2 million volumes, 26,000 electronic journals and 300,000 photographs. In many cases digital collections, publishing and services are at the heart of the institutes' libraries, such as for the Institute of Historical Research (IHR), which includes resources such as <i>British History Online</i> and <i>Bibliography of British and Irish History</i>. The growing research in Digital Humanities includes projects such as Born Digital Big Data, looking into challenges of collecting, describing, preserving, publishing and analysing born-digital data.

Institution	Key assets
Central Saint Martins (UAL)	Central Saint Martins (UAL). The Digital Archives and Collection (DAC) project aims to put in place the infrastructure and software applications for the management and preservation of digital assets, and for their discovery and engagement, so that UAL collections can be leveraged for teaching, learning and research, and for public and scholarly engagement beyond UAL. The university holds important cultural archives and collections, including the Stanley Kubrick Archive, British Artists' Film and Video Collection, and the Tom Eckersley Collection ⁴⁹ .
Birkbeck, University of London	Vasari Research Centre: Digital technologies and devices relevant to the research and study, as well as production and exhibiting, of the arts continue to evolve. The centre plays an increasing role in integrating digital research and providing specialist support. It maintains and digitises important analogue material, assists and initiates funding applications and is currently examining the emerging area of 3D scanning and reconstruction in museums, galleries and higher education as well as the development of open educational resources in the arts.

Source: Data from the named institutions and/or SQW's review of their websites

5.8 The Knowledge Quarter's digital collections are comparable to those found in other world cities with significant levels of spatial aggregation and a concentration of leading institutions. The table below shows key organisations and initiatives in Washington D.C., New York City/ Boston, and Paris. (The focus of the table is on institutions which either have large digital collections or use innovative digital approaches and methods.) Similar (if usually smaller) digital cultural and creative clusters also exist in other parts of Europe such as Berlin, Amsterdam and Scandinavian cities, as well as in East Asia, especially in Seoul, Beijing, and Shanghai.

Table 5-2: Comparator analysis of digital collections

City	Key institutions	Digital Collections	Key initiatives
Washington DC	- Library of Congress - Smithsonian Institution and Smithsonian Libraries - National Archives - Institute of Museum and Library Services (IMLS) - University of Washington - Georgetown University - George Washington University - University of Maryland - George Mason University - Council on Library and Information Resources - Publishers and digital media: National Geographic Books, IMF Press, Washington Post, Kaplan Inc	- Library of Congress: 74 terabytes digitised and freely available on the Internet. 15.3 million digital items online. - Smithsonian Libraries: 27,000 digitised books and manuscripts - Smithsonian Institution: 7m data objects and nearly 4m images - University of Washington Libraries: 1.2 million locally digitized items; 2 million downloads	- Library of Congress: US National Digital Information Infrastructure and Preservation Program, established in 2000 with initial funding of US\$100m, includes 130 partners. - Library of Congress: UNESCO World Digital Library. - Smithsonian Enterprises Digital Services: presenting museums with the opportunity to upgrade and enhance their presence online. - National archives: President Obama's digital presidential library. - Digital Library Foundation with 160 member institutions across the US. - Digital Scholarship Centre, George Mason University.

⁴⁹ Note that these collections are held by the university across its sites, not just at CSM

City	Key institutions	Digital Collections	Key initiatives
New York and Boston	- New York Public Library - New York State Archive - New York Historical Society - Boston Public Library - Digital Public Library of America - The Andrew W Mellon Foundation - Metropolitan Museum of Art - MoMA - New York University - Columbia University - Harvard - MIT - Publishers and digital media: Penguin Random House, Hachette Book Group, Harper Collins, New York Times	- New York Public Library: 743,177 digital items, of which 180,000 in the public domain - Metropolitan Museum of Art – 440,000 works of art digitised - MoMA – 77,000 works of art on-line - Columbia University – 435,000 digitised items	- Digital Public Library of America (DPLA) – 22m photographs, documents, videos and sounds from across the US - Digital Commonwealth: Massachusetts Collections Online – 160 members across the State - The Andrew W Mellon programmes funding for pioneering cultural and arts digital programmes, libraries and scholarly communications - MIT Media Lab - Harvard and MIT MOOC and online learning platforms
Paris	- Bibliothèque nationale de France - Archives Nationales - Atelier des Lumières – digital arts centre - Louvre Museum - Sorbonne University - University of Paris - Publishers and digital media: Éditions du Seuil, Éditions Grasset & Fasquelle, Groupe Flammarion, Éditions Gallimard, Albin Michel	- BnF, Gallica: 4.3 million documents available online. These include around 2.1 million press articles; 1.2 million images; 625,000 books; 360,000 objects; 140,000 maps, and more than 50,000 music scores - Louvre – 30,000 entries in the Atlas Database - Archives Nationales: 200m digital files	- Gallica - Paris Digital Lab - FeniXX is the company created by the French publishers to digitise 200,000 books over a nine year period. - Ground-breaking immersive Klimt exhibition at the Atelier des Lumières - Sorbonne Universités labellisés Laboratoires d'excellence (Labex)

Source: Data compiled by Technopolis and the British Library

5.9 Collaborations already exist between KQ organisations and some of these comparator institutions. For example, the British Library and Bibliothèque nationale de France operate under a memorandum of understanding (MoU) that includes a joint development of digital assets, new digital services and research methods. Recently, these two institutions created a collaborative digital resource by digitising 400 English and French pre-1200 manuscripts,⁵⁰ funded by the Polonsky Foundation.

⁵⁰ <https://www.bl.uk/projects/polonsky-foundation-england-and-france-digitisation-project>

Local science and innovation talent

- 5.10 The KQ's cultural institutions are major employers. Office for National Statistics (ONS) data show concentrations of employment. Libraries, museums and archives and publishing all have higher concentrations of employment than would be expected were such jobs spread evenly across the country.

Table 5-3: Business numbers and employment by industry group (for Camden and Islington)

Industry group	Local (business) units	Employment	Location Quotient (average = 1.0)
Publishing of books, periodicals, etc.	545	12,000	4.89
Creative, arts and entertainments	2,035	6,000	3.74
Libraries, archives, museums and other cultural	85	3,600	1.92

Source: BRES (2016); UK Business Counts (2017)

- 5.11 The KQ's institutions draw talent from across the UK and internationally. Staff come from a huge range of disciplines, from across the physical and biological sciences as well as the social sciences and the humanities. There are a sizeable number of study programmes in the Knowledge Quarter related to collections, especially at postgraduate level. City University runs masters' programmes in Library Science and Information Science, while SOAS has courses in History of Art, and Archaeology. The largest number of courses, though, seems to be at UCL, which runs programmes in information studies, museum studies, artefact studies and cultural heritage (among others), courses which often draw on the university's wider strengths in, for example, anthropology and archaeology. Its degree programmes also increasingly reflect the shift to digital: examples include its MA/MScs in Digital Humanities and its MSc in Computational Archaeology. UCL also offers degrees in Publishing, a programme that draws on industry experts for some of its teaching, and Archives and Record Management. Central Saint Martins, meanwhile, has a small but growing area of work related to digital archiving, curation and publishing, delivered in part through its Communication Design department.
- 5.12 The KQ is also a major producer of creative talent. Central Saint Martins (University of the Arts London) is one of the world's leading creative institutions with specialisms in art; product, ceramic and industrial design; culture and enterprise; drama and performance; fashion; graphic communication design; and jewellery and textiles. The KQ is also home to several University of London colleges, such as UCL and SOAS, which have strengths in creative education, and world-leading specialist creative education bodies, from the Architectural Association to RADA.

Local industrial strengths and capacities

- 5.13 Creative companies in KQ range widely, from Ted Baker and Louis Vuitton UK in fashion, Thomas Heatherwick Studios and Zaha Hadid Architects in architecture and design, and the Gagosian and Pangolin London art galleries. KQ is also home to important public bodies for the sector, such as Arts Council England, the Design Council and the Crafts Council.

- 5.14 In the context of the SIA, the concentration of publishing firms is especially significant⁵¹. Many of these firms have devoted considerable resources to developing digital products and services that draw on their own archives of previously-published work. The KQ has also seen the emergence of a new generation of ‘born-digital’ publishers that take advantage of the new business models enabled by digital technology. KQ has also become a centre of other forms of digital publishing. It is the main UK base of Google and its subsidiary YouTube, and is due shortly to become the UK base of Facebook. It is also home to the Guardian and Observer newspapers. Examples of leading publishing firms in the area are provided below.

Table 5-4: Selected publishing firms within KQ

Organisation	Description
Bloomsbury Publishing	Bloomsbury is a worldwide publishing house of both fiction and non-fiction. The company is best known as the publisher of J.K. Rowling's <i>Harry Potter</i> series, but it also has an academic and professional publishing division. The latter includes Bloomsbury Digital Resources, launched in 2017. It provides scholarly content in the humanities and social sciences, and continues to launch new products to build on the likes of Bloomsbury Fashion Central and Drama Online.
Bookouture	Founded in 2012, and bought by Hachette UK in 2017, Bookouture is a ‘born digital’ publisher. It supports its selected authors with marketing and publicity campaigns tailored to each book and optimised for the digital environment, including, for example, their metadata for Amazon
British Library Publishing	British Library Publishing produces books across a wide range of subjects related to the Library's collections, including maps, medieval manuscripts, literary history, graphic design and typography, the history of books and cultural history.
British Medical Journal (BMJ)	Since its founding in 1840, the BMJ has grown to become one of the world's most cited general medical journals. However, it is only one part of the organisation's' activities: it publishes more than 55 peer-reviewed specialist journals across a range of medical and allied science fields. The BMJ is a leader in digital publishing and open access, and draws on in-house teams of clinical writers, editors, health economists and information specialists alongside a worldwide network of experts
Faber & Faber	Faber & Faber is an independent publishing house founded in the 1920s that publishes fiction, non-fiction, poetry, and drama, including the work of T. S. Eliot, Ted Hughes, Harold Pinter, Sylvia Plath, William Golding, Samuel Beckett, Seamus Heaney and Kazuo Ishiguro. Faber & Faber is also a contributor to Drama Online, an online resource of more than 1,200 play texts, both ancient and modern, critical analysis, videos of performances and practical guides
Pan Macmillan	With a history (and booklist) dating back to the 1840s Pan Macmillan is a central part of the worldwide Macmillan Group. It publishes both fiction and non-fiction, under several publishing brands. Its science and education division, which published the journal <i>Nature</i> , merged with Springer in 2015 to form Springer Nature (see below)
Phaidon Press	Phaidon is a leading global publisher of books on art, architecture, photography, design, performing arts, decorative arts, fashion, film, travel, and contemporary culture. Founded in Vienna in the 1920s, it was moved to London in the late 1930s. Its titles include <i>The Story of Art</i> by Ernst Gombrich, reportedly the world's bestselling artbook, and it has over 1,500 titles in print. It produces many lavishly illustrated digital books
Springer Nature	Now part of the Holtzbrinck group, Springer Nature is a major publisher of scientific research, including through open access. Its publications include <i>Nature</i> and <i>Scientific American</i> . In 2016 Springer Nature launched Springer Nature SharedIt, which enables authors and subscribers to share research more easily, via social media, repositories, scholarly collaboration networks and email, as well as facilitating free access to the research via over 200 major media outlets (such as The Guardian and the BBC) across the world. It has also created SciGraph, a Linked Open Data platform, that aggregates data sources and allows users to explore connections between bibliographic metadata statements to make data more accessible and reusable to help advance research discoveries.

Source: Data drawn from company websites

⁵¹ Frontier Economics estimated the UK publishing industry had a turnover at £5.1bn in 2016, with export sales accounting for well over half that total, at £2.9bn (Frontier Economics (2017) *The Contribution of the Publishing Industry to the UK Economy: A report for the Publishers' Association*)

- 5.15 *Scholarly publishers* comprise a significant subset within the Knowledge Quarter publishing ecosystem. This set of firms is undergoing its own re-shaping, related to digitally-driven changes in education and research. Of particular significance has been a policy-driven change towards enabling open access (OA) of scholarly content. Key examples are summarised in the table below.

Table 5-5: Open Access Publishers started by universities and scientific bodies within the KQ

Organisation	Description
Wellcome Trust	Wellcome Trust has been a leader in facilitating open access to scholarly research. In 2005, Wellcome became the first research funder to introduce a mandatory open access policy. This specified that research articles that were supported in whole or in part by its funding had to be made open access as soon as possible, and in any event within six months of publication. It has also launched Wellcome Open Research, a platform that provides all Wellcome researchers with a place to rapidly publish their research results Wellcome Trust requires researchers to make their publications available via PubMed Central , a free, global digital repository that archives publicly accessible full-text scholarly articles. This service was established in the UK as a partnership with the British Library, University of Manchester and the European Bioinformatics Institute, led by the Wellcome Trust, in 2007
UCL Press	Launched in 2015, UCL Press is the UK's first fully open access university press, with a focus on books and monographs. Its platform offers many tools and functionalities to engage with scholarly content, including the new UCL Press mega-journal platform. Mega-journals are a new concept in publishing, bringing together studies in a variety of related academic areas.
Open Library of Humanities	Open Library of Humanities is a non-profit open access publisher for the humanities and social sciences led by the academics Martin Paul Eve and Caroline Edwards from Birkbeck. This new model extends Open Access innovation into the humanities, developing new business models for this sector
The Humanities Digital Library	The Humanities Digital Library is the open access library and catalogue for books published by the School of Advanced Study, University of London. It forms part of the School's mission to embrace the opportunities of digital content delivery and enable greater access to knowledge. The HDL is building publishing partnerships with bodies such as the Royal Historical Society, in order to help them transition to an open-access environment.

Source: Data drawn from organisations' websites

- 5.16 Other major publishers in the KQ area include: Africa Confidential; Eland Publishing; Facet Publishing; Guardian News and Media; Hurst Publishing; Jessica Kingsley Publishers; London Review of Books; MixMag Media; New Scientist; Pavilion Books; Profile Books; Quarto Publishing Group UK; Quercus; Scholastic; The New Economy; Times Higher Education/ TES; World News Media; and Yale University Press.
- 5.17 The other major constituency in the ecosystem depicted in Figure 5-1 is the digital sector. This itself is both large and evolving quickly. It is the focus of Chapter 6.

National and international engagement

- 5.18 The major collections based in the KQ have significant national and international links. Indeed, these institutions regard major international collections as their benchmarks. The British Museum, for example, often compares itself against the Metropolitan Museum in New York, the Louvre in Paris and the Hermitage in St Petersburg, while the British Library looks to the Bibliotheque nationale de France in Paris.

National linkages

British Library

- 5.19 The **British Library** collaborates with universities and research organisations on both research and infrastructure related projects (43 projects in 2016-17). Collaborators include UK academic and public libraries, IROs, the Alan Turing Institute, FutureLearn, international and national cultural bodies. It also collaborates with large businesses, including on large digitisation programmes, which are established as public/private partnerships with companies such as Google and DC Thomson.
- 5.20 The British Library has six purposes, one of which is to help businesses innovate and grow. One of its services for business is the **Business and Intellectual Property Centre (BIPC)**. Since its launch, the BIPC has welcomed over 550,000 people through the doors and supported over 100,000 SMEs through its programme of workshops. From its base in KQ, BIPC supports businesses across the UK, as Box 5-2 demonstrates.

Box 5-2: British Library's Business and Intellectual Property Centre (BIPC) and the examples of businesses supported through it in London and elsewhere in the UK

The BIPC offers a wide range of resources for free: over £5m worth of online market reports from Mintel, Frost & Sullivan, Euromonitor and more; company data for over 144 million UK and global companies; start-up books and business directories, 700,000 historical annual reports, and 60 million patent records.

The BIPC supports ambitious scale-ups via its 'Innovating for Growth' programme, part-funded by the European Regional Development Fund. The programme helps small businesses to grow through advice and mentoring on maximising their IP, new national and international markets and new business models. Phase 1 (January 2012 – December 2015) of the project helped a total of 241 businesses to create an additional 249 jobs and £16m in GVA, a number that continues to grow. The BIPC has 300+ alumni businesses in its Growth Club, which have participated in its 'Innovating for Growth' programme.

Examples of beneficiary businesses exist both in London and further afield. For example:

- **Ohyo (London):** Guy Jeremiah invented the Ohyo collapsible water bottle when he had a "light bulb moment" in a train station. Having seen an advert on the tube declaring "Got a great idea, we can help you protect it", he made his way to the then newly-formed Business & IP Centre at the British Library, which helped him to establish that the design was patentable and, furthermore, did not breach anyone else's patent. This gave him the confidence to invest the time and cash to develop the idea and protect his intellectual property. Today Ohyo bottles are stocked by a large number of major retailers and are exported all over the world.
- **REALRIDER® (Newcastle):** REALRIDER® is a smartphone app devised by entrepreneurs and motorcycling enthusiasts Zoe Farrington and Andrew Richardson. It automatically detects if a motorcycle rider has been involved in a crash by using motion sensors which send an alert to the rider's phone. If the alert isn't cancelled, the app immediately contacts the ambulance service with the location and pre-programmed medical details of the rider. When working with the Great North Air Ambulance in 2006, Zoe and Andrew had discovered that motorcycle riders being thrown from their bikes was a big cause of death. Accidents often occur on rural roads and during solo rides so finding these riders within the 'Golden Hour' to help improve their chances of recovery is imperative.

Source: Data supplied by the British Library

- 5.21 In the last couple of years, the British Library has drawn on the BIPC experience to roll out a national network of Centres in ten other city libraries across England. The Centres are physical hubs where people can come together to learn, network and access free and low-cost information and support in protecting and commercialising a business idea or a creative work. The Centres are found in central libraries in Birmingham, Exeter, Hull, Leeds, Liverpool, Manchester, Newcastle, Norwich, Northampton and Sheffield. This network is set to grow with a plan for twenty Centres by 2020.

- 5.22 The Network has the potential to create businesses and jobs in cities across England due to its effective use of existing resources and public buildings, as well as its unique public/private partnership model. All the libraries are part of the Patent Library network, and thus have IP databases and expertise, as well as up-to-the-minute electronic company, financial and market research data. Together, the network supported over 16,500 people in 2016/17, with women (59%) and Black, Asian and minority ethnic groups (35%) particularly well represented.
- 5.23 A similar spirit of collaboration marked the launch of the *Living Knowledge Network* in September 2016. Funded by Arts Council England, this is a nationwide pilot partnership between the British Library and the National Libraries of Scotland and Wales, Libraries NI (Northern Ireland) and 21 major public libraries across the UK. Building on the BIPC network, it aims to strengthen the collective ability of libraries to deliver services to diverse communities.

British Museum

- 5.24 Working with museums and galleries across the UK, the **British Museum** provides training, staff development and platforms for sharing knowledge and research. As part of the BM's current *Skills for the Future* programme, supported by the Heritage Lottery Fund (HLF), young people across the UK receive training in collections management and public engagement. The HLF also supports the Collections Skills Training Programme. The scheme gives UK museum staff and volunteers access to free training at the BM's World Conservation and Exhibitions Centre.
- 5.25 With support from the Vivmar Foundation, BM's long-running *Knowledge Share* programme continues to deliver professional development opportunities for UK museum staff and volunteers. In 2016/17, BM partnered with institutions in County Durham, Nottinghamshire, Warwickshire, Dorset and London to create ten staff exchanges.

Box 5-3: Examples of digital projects linked to the British Museum

- **MicroPasts** is an online crowdsourcing platform developed jointly by the British Museum and UCL to support the archaeological sector. It aims to bring human intelligence to bear on tasks that computers alone cannot do. There is a wide variety of tasks with which volunteers can engage, from tagging YouTube videos about the Roman Empire to transcribing royal seals. The partnership has recently been extended to include Cambridge University Museums and the University of Stirling. MicroPasts projects are required to deposit final datasets in one of a small number of permanent data repositories
- **Scan the World** is a London-based community-built archive of scanned cultural objects (usually sculptures) that have been optimised for 3D printing. The objects are photographed from many (overlapping) angles and through a software-driven process called photogrammetry a scan is created. Scan the World currently has over 11,000 objects scanned for 3D printing. More than 50 museums and galleries from across the world support the project, and include the British Museum, Islington Museum, Cardiff Museum, the V&A, the Art Institute of Chicago, the Getty Center (Los Angeles), the Louvre, the Metropolitan Museum (New York) and the Hermitage Museum.
- **Sketchfab** is a platform (and related store) that allows people to publish, share, and discover 3D content on web, mobile, AR, and VR. It describes itself as "the world's largest platform for immersive and interactive 3D". The British Museum has a Sketchfab page on which it shows almost 250 objects from across its collections. Sketchfab's functionality allows for the 3D models to be explored in a number of ways, including through VR. If a model is downloaded from the Sketchfab store then the British Museum receives a fee of between £30 and £1,000.

Source: Data gathered from websites by SQW, then reviewed by the British Museum

UCL Collections

- 5.26 As Table 5-1 explained, UCL houses important collections especially in the fields of art, archaeology and ethnography. The box below describes the outreach around UCL's Special Collections.

Box 5-4: UCL Collections - Special Collections Outreach programme

The main aim of the Special Collections Outreach programme is to create meaningful experiences for non-academic audiences (especially those identified as priority groups) to access, learn about and enjoy UCL's Special Collections. Key projects in 2017 included:

- **Time Capsule** with Edith Neville Primary School: a whole-school project developed around the building of a new school and the demolition of the old. In collaboration with Museum of London Archaeology, the children explored the concept of keeping things for the future as well as the importance of objects from the past. As part of this, pupils were taught about archives and each class has begun to create a class archive.
- **Making East London:** with funding from HLF and a UCL Beacon Bursary, this touring exhibition was a collaboration with Newham Libraries and Archives (East) to bring together both organisation's collections to explore East London's past, inspired by the Main Library exhibition *East Side Stories*. The exhibition was a centrepiece around which workshops for community groups were run. The workshops were also opportunities for the recording of local peoples' stories, experiences and memories of east London; student volunteers from UCL have worked to, and continue to, record oral histories as part of a new digital archive.

Source: UCL

Examples of international engagement

- 5.27 The **British Library** engages with many overseas institutions, including working with diplomatic representatives. It collaborates with other national libraries and bodies (e.g. in India, Argentina, South Africa, France, China, and Qatar) and through relevant professional organisations. Currently, it chairs the Conference of European National Libraries. The Library runs many international projects: one example is the *Two Centuries of Indian Print*, supported by the Newton Fund, to digitise rare material from South Asia.
- 5.28 Other examples of international projects involving the British Library are summarised below.

Box 5-5: Examples of international projects involving the British Library

- **Qatar Digital Library:** In April 2018 Qatar Foundation and the British Library announced the third phase of their partnership to continue digitising the British Library's historical collections on the Arabian Gulf region. The ongoing digitisation project, one of the largest of its kind, started in 2012. The first two phases digitised more than 1.5 million pages, which are now accessible on the Qatar Digital Library (www.QDL.qa). The QDL is a free online digital archive that has had more than one million users and 8.8 million page views since its launch in October 2014. Phase 3 of the project will involve the digitisation of 900,000 pages of new material on the Arabian Gulf as well as Arabic manuscripts on science. The Gulf-related material includes music, maps, ships' logs, reports, letters, private papers and historical publications.
- **International Dunhuang Project:** IDP is a ground-breaking international collaboration to make information and images of all manuscripts, paintings, textiles and artefacts from Dunhuang and archaeological sites of the Eastern Silk Road freely available on the Internet and to encourage their use through educational and research programmes. IDP's directorate was established at the British Library and it has centres in China, Russia, Japan, Germany, France and Korea. IDP is the largest and most successful project of its kind, providing information on tens of thousands of paintings, artefacts, textiles, manuscripts, historical photographs and maps as well as cataloguing and contextual information. This project provides resources to all levels of users from schoolchildren to post-doctoral researchers.

Source: British Library

- 5.29 The **British Museum** has extensive international linkages. In 2016/17, BM loaned over 2,200 artefacts to 113 venues outside the UK. Many supported special exhibitions organised by

museums around the world. Box 5-6 below provides some examples of the British Museum's international activity.

Box 5-6: Examples of the British Museum's international activity

- In May 2016, scientists from the BM visited the Hermitage Museum in St Petersburg to initiate collaborative research on Scythian artefacts displayed in the *Scythians: Warriors of Ancient Siberia* exhibition. On a return visit Russian colleagues advised on material in the BM collection.
- Curatorial collaboration abroad included research on Vikings with the University of Uppsala, Sweden; on Captain Cook's voyages with the Tairāwhiti Museum, New Zealand; and on Parthian coins with colleagues in Iran and Austria. A staff exchange with the National Museum of Denmark was renewed.
- In 2015, in response to the destruction of heritage sites in Iraq, the BM set up the Iraq Emergency Heritage Management Trainee Scheme. The first group arrived at the BM in May 2016, and a second in January 2017, before undertaking fieldwork at two sites in Iraq. The scheme is already having an effect: one 2016 alumnus has been appointed to lead the assessment of the site of Nimrud, recently released from ISIS control.
- The BM received generous support for new projects. The Australian Research Council is supporting a four-year project on Western Australia called *Collecting the West* that will shed new light on Aboriginal collections in the BM and around the UK. *Innovation, Dispersal and Use of Ceramics in North-East Europe* is a major partnership with museums and universities in Germany, Russia, Poland, Denmark, the Baltic States and the UK. The five-year study looks at the origins and use of pottery vessels by hunter-gatherers across northeast Europe, and is funded by a European Research Council grant of €3.1m.
- As part of the International Training Programme, museum professionals from around the world come to the BM to work with staff in relevant departments every summer. They also spend ten days at different museums around the country, looking at other models of museum practice, governance and funding, as well as local collections and community links which may more closely mirror the participants' own institutions. In 2016, 21 fellows were invited from 13 countries.
- Since 2008, the BM has been associated with a project to create the new Basra Museum in Iraq. The initial stage of this project, primarily funded by BP, saw the first gallery, devoted to the history of the Basra region from 300 BCE onwards, formally opened on 27 September 2016. The museum's director, Qahtan Alabeed, is an alumnus of the BM's International Training Programme and the BM continues to offer its support.
- The Egyptian Museum and the Egyptian Ministry of Culture both hold tens of thousands of glass negatives of photographs dating from the 1860s to the 1950s in their archives. Glass negatives are extremely fragile and need special care, but are an important historical record. A year-long project between the two Egyptian archives and the British Museum (supported by the Arcadia charity) sought to document, digitise and preserve these negatives. Over 15,000 glass negatives have been through the process to date, and are available online for researchers and members of the public to view.

Source: British Museum

- 5.30 **SOAS**, University of London is the only higher education institution in Europe specialising in the study of Asia, Africa and the Near and Middle East. SOAS uniquely combines language scholarship, disciplinary expertise and regional focus.

Box 5-7: SOAS projects

- In spring 2016 in Delhi SOAS held a major exhibition exploring the cultural history of Zoroastrianism, sponsored by the Government of India's Ministry for Minority Affairs (MOMA). *The Everlasting Flame: Zoroastrianism in history and imagination* was produced by SOAS and developed in collaboration with the British Library and UNESCO Parzor. Originally exhibited at SOAS' Brunei Gallery in 2013 – a leading London gallery hosting contemporary and historical exhibitions from Asia, Africa and the Middle East – the exhibition received widespread acclaim in national and international press and was visited by more than 23,000 people.
- Endangered Languages Archive (ELAR) is a digital repository preserving and publishing multimedia collections of endangered languages. The archive contains collections from all over the world with regional strongholds in Africa, the Middle East, Asia, Australia and Latin America. To date, recordings encompassing over 450 languages can be found in ELAR. Collections in ELAR contain audio and video recordings of everyday language use, verbal art, songs, narratives, ritual and more. The collections also contain dictionaries, pedagogical materials like primers for language teaching, transcriptions and translations of the recordings into the major contact language: Spanish, Mandarin, English or Russian, for example. ELAR was originally funded by Arcadia in 2002 and became part of the SOAS library in 2014.

Source: SOAS

Developments in the wider funding landscape

- 5.31 The main collections are funded from a range of sources. These include grant funding from DCMS and other bodies (e.g. Heritage Lottery Fund); fundraising and philanthropy, including from overseas; and commercial activity. Recent developments in the funding landscape need to be understood in this context.
- 5.32 Within KQ, there is evidence of the importance of major charities in relation to the main collections and cultural institutions. For example, the **Wellcome Trust** pledged a major sum in support of the BM's new scientific research programme in bioarchaeology. The funding reflects the increasing importance of molecular analysis to museum research as well as the scholarly benefits of the BM's new World Conservation and Exhibitions Centre (WCEC).
- 5.33 Funding from central government continues to be very important, but the formation of UKRI and the transition towards funding that reflects major (social and economic) "challenges" are increasingly shaping the landscape. In this context, the *Industrial Strategy Challenge Fund* is a core pillar in the government's commitment to increase research and development by £4.7 billion over four years to strengthen UK science and business. Some elements of it are directly or indirectly relevant to the collections theme. For examples, the *Creative Industry Clusters Programme* (which was initiated by the Arts and Humanities Research Council) is seeking to support research and development partnerships that generate a step-change in the creative industries, develop new products and services and create jobs with high value skills. Similarly, it was announced in March 2018 that some £33 million would be made available from ISCF for new products and services that exploit immersive technologies⁵².
- 5.34 The UKRI investments are linked to the *Creative Industries Sector Deal*,⁵³ which aims to make Britain the best place in the world for the creative industries to thrive. For example, the Sector Deal aims to double Britain's share of the global creative immersive content market by 2025.

⁵² See <https://www.gov.uk/government/news/immersive-technologies-for-audiences-of-the-future-new-funding>

⁵³ As part of the Industrial Strategy, the government and the Creative Industries Council (CIC), have agreed a Sector Deal on behalf of the creative industries to "unlock growth for creative businesses". The Sector Deal includes an investment programme of more than £150m, intended to support activity across different stages of the lifecycle of creative businesses,

- 5.35 Policy commitments identified in the DCMS's *Culture is Digital* report are also of relevance⁵⁴. These include the use of technology to drive audience engagement, boosting the digital capability of cultural organisations, and unleashing the creative potential of technology.

Conclusions and future potential

- 5.36 The major collections within KQ constitute a substantial national asset and they are a huge repository of "content". Increasingly, the collections are being digitised which means that they are becoming far more accessible and, as a resource, far more powerful.
- 5.37 This process, however, is complicated. The collections themselves have a wide range of purposes, many of which relate broadly to increasing knowledge and widening access to it. Generally, commercial goals are well down the list. Indeed, a written response from one of the major collections to the SIA's call for evidence was telling. When asked "*how much of a priority for your organisation are opportunities for commercialising your digital collections*", the response was simply "*it isn't a priority; indeed, we recently closed our commercial image library to focus on open access*".
- 5.38 Through the SIA, we have found that:
- The **digitisation process is a catalyst for innovation**, especially in precipitating new partnerships with the private sector to:
 - enable digitisation (e.g. BL with Google and DC Thomson)
 - deploy new technologies in delivering services to audiences (e.g. BM with Samsung)
 - **Many holders of cultural, scientific and heritage collections collaborate with other KQ-based organisations.** The great range of such organisations offers tremendous scope for interdisciplinary exchange. However, there is potential for much more, with particular opportunities for organisations at different stages in their digital 'journey' to learn from each other.
 - The larger, more established, **collection-based organisations act both as place-makers and as catalysts for relationships within the Knowledge Quarter.** Local examples include interactions such as the use of the UCL Special Collections in work with local schools.
 - At the same time, however, these organisations also provide infrastructure for extensive national connections (e.g. the BIPC work with public libraries across the UK), and international connections (e.g. the British Museum's International Training Programme). **The depth of national and international links is especially rich and at times takes precedence over deepening local collaborations.**

⁵⁴ DCMS (2018) *Culture is Digital Executive Summary*, p16-17

- In securing the benefits of digitisation, there are **tensions between open access and commercial approaches**. While new models are emerging in scholarly publishing, both in the commercial sector and through the university initiatives such as the UCL Press and the Open Library of Humanities, commercial models are less readily deployed in relation to collections. The DCMS' *Culture is Digital* report recommends more focus on new business models and commercial opportunities, but the mechanisms for achieving these are unclear.
- **Collaborations with technology organisations and data sciences present a major opportunity to produce new methods of using digital content**, including the use of AI and machine learning in managing and understanding collections data, as well as AR/VR to develop new products and services that would engage new audiences.

5.39 The inference is that the collections are a huge enabler of innovation without – perhaps – being a focus for it, other than in respect of the management of the information they contain. This in itself should not be underestimated, as the volume of material they are processing is rising rapidly and all of the major collections are working collaboratively with partners locally, across the UK and internationally. The digitisation of collections has been a focus for innovation in its own right and the links across to the digital theme – explored in detail in the next chapter – are powerful, important, and developing quickly.



6. Theme 3: Data science

Chapter Summary:

Artificial intelligence will impact across all sectors of the economy: it is estimated that the exploitation of AI could add around £580 billion to UK GVA by 2035, and the UK is claimed to have the strongest AI and machine learning market in Europe.

In this context, the Knowledge Quarter has significant strengths. Among its universities, UCL is the highest ranked university for computer science in the UK by grade point average, and the KQ's universities have a range of multi-disciplinary research centres. Beyond the universities, nationally significant assets include the Alan Turing Institute and institutions such as the Digital Catapult.

There is also major corporate investment in data science in the Knowledge Quarter. Google's new campus at King's Cross is worth around £1 billion; most data science businesses are very young and investment activity (including from the major tech businesses), and the pace of technological innovation, are high.

Within the Knowledge Quarter, there are strong links between the research base and the growth of data science businesses: the founders of DeepMind, for example, retain strong connections to the university base. The ability to attract and retain talent is vitally important in a highly competitive market for data science skills: recently, the Knowledge Quarter has proved attractive as a destination for researchers and entrepreneurs, and this will be critical for the future.

Scope – and links to our hypotheses

- 6.1 The Knowledge Quarter hosts an impressive concentration of research and commercial assets in relation to data science. In the commercial world, **DeepMind**, a world leader in artificial intelligence, was established by UCL academics and was acquired by **Google** in 2014: currently, it is based in Google's UK headquarters in Pancras Square, and is due to expand substantially in the next few years. Among other businesses focused on the exploitation of data science, **Benevolent AI** (based on Churchway, near Euston) is the world's largest private artificial intelligence firm, with strong links with the biotechnology sector (and hence an interest in two of the KQ SIA Themes).
- 6.2 The Knowledge Quarter's commercial strengths are underpinned by substantial academic assets. These include the Centre for Computational Statistics and Machine Learning, the Centre for Data Science and the Big Data Institute at **University College London**. **City, University of London** and **Birkbeck** also offer extensive capabilities. Beyond the universities, the Knowledge Quarter also hosts the **Alan Turing Institute**, the national institute for data science and artificial intelligence, based at the British Library. Other national data science institutions based in the Knowledge Quarter include the **Digital Catapult**, headquartered in Euston Road, which seeks to drive the commercial adoption of advanced digital technologies.
- 6.3 Within this context, the Data Science theme of this Audit is particularly focused on the Knowledge Quarter's strengths in **artificial intelligence and machine learning**. These technologies will have impacts across the economy, including in relation to the other themes of this SIA.

National and international trends, and size of global markets

Defining artificial intelligence

- 6.4 Artificial intelligence is concerned with the development of computer systems that are able to “sense their environment, think, learn and take action as a result”⁵⁵. This ability to respond to the environment enables artificial intelligence technologies to “reproduce or surpass abilities (in computational terms) that would require ‘intelligence’ if humans were to perform them”, moving beyond the automation of routine tasks⁵⁶. Within this overall definition, the concept of artificial intelligence embraces a range of specific techniques and technologies (including machine learning⁵⁷), which seek to develop:
- **audio and visual processing**, enabling machines to accurately perceive the world around them (for example in the use of facial recognition)
 - **natural language processing**, enabling systems to collect, analyse and understand complex information from multiple sources
 - **autonomous action**, using data and sensors to take actions in the physical world (for example in the development of autonomous vehicles)
- 6.5 A recent Government review of the artificial intelligence industry highlights the extent to which these technologies and activities are complementary, interlinked and evolving, and should be considered together⁵⁸.
- 6.6 The *concept* of artificial intelligence is not new: as long ago as 1950, Alan Turing discussed the idea of ‘machine thinking’. However, two key factors have led to an acceleration in progress in recent years: first, unlimited access to computing power and abundant data storage; second, an explosion in ‘big data’ as more devices become connected⁵⁹. Growth in data is central to the expansion of AI: the greater the number of data ‘examples’, the greater the accuracy of artificial intelligence technologies.

Key applications

- 6.7 Despite this recent acceleration – and very significant policy interest – artificial intelligence is still at a relatively early stage of development. Table 6-1 highlights some of the big areas of opportunity, and potential applications over the short, medium and longer terms:

⁵⁵ PwC (June 2017), *The economic impact of artificial intelligence on the UK economy*, p.5. It should be noted however that a variety of different definitions have been proposed, which have changed over time as technology has advanced. See (for example), of London/ CognitionX (2018), *London: The AI Growth Capital of Europe*, p.20

⁵⁶ Engineering and Physical Science Research Council, <https://epsrc.ukri.org/research/ourportfolio/researchareas/ait/>

⁵⁷ Defined as “the ability of machines to progressively improve their performance without humans having to specify each task”. See Erik Brynjolfsson and Andrew McAfee (July 2017), ‘The business of artificial intelligence’, *Harvard Business Review*, <https://hbr.org/cover-story/2017/07/the-business-of-artificial-intelligence>

⁵⁸ Professor Dame Wendy Hall and Jérôme Pesenti (2017), *Growing the artificial intelligence industry in the UK*, p. 8

⁵⁹ Mark Purdy and Paul Daugherty (2017), *Why artificial intelligence is the future of growth*, Accenture, p.11

Table 6-1: Big opportunities for artificial intelligence

Areas with the biggest AI potential	Timing of potential applications...		
	Ready now	Medium term	Longer term
Healthcare			
- Supporting diagnosis in detecting small variations - Early identification of potential pandemics - Imaging diagnostics (radiology, pathology)	Medical insurance and smarter scheduling	Data-driven diagnostics and virtual drug development	Robot doctors carrying out diagnosis and treatment
Automotive			
- Autonomous fleets for ride sharing - Semi-autonomous features (e.g. driver assist) - Engine monitoring and predictive maintenance	Automated driver assistance systems (e.g. parking assist)	On-demand parts manufacturing and maintenance	Engine monitoring and predictive, autonomous maintenance
Financial services			
- Personalised financial planning - Fraud detection and anti-money laundering - Process automation, inc. customer facing operations	Robo-advice, automated underwriting and robotic process automation	Optimised product design based on consumer preferences	Moving from <i>predictive</i> to <i>prescriptive</i> analytics
Retail			
- Personalised design and production - Anticipating customer demand – e.g. predicting orders in advance - Inventory/ delivery management	Product recommendations based on preferences	Fully customised products	Products that anticipate demand from market signals
Technology, communications and entertainment			
- Media archiving and search - Customised content creation - Personalised marketing and advertising	Content recommendation for consumers	Automated telemarketing capable of holding a 'real' conversation	Use-case specific and individualised content
Manufacturing			
- Enhanced monitoring and auto-correction of manufacturing processes - Supply chain/ production optimisation - On-demand production	Greater automation of a large number of production processes	Intelligent automation – e.g. supply chain optimisation and predictive scheduling	Using predictive analytics in product design – solving problems and shaping outcomes
Energy			
- Smart metering and real-time information on usage - More efficient grid operation and storage - Predictive infrastructure maintenance	Smart metering	Optimised power management	More efficient and consistent renewable energy supply – e.g. wind power
Transport & logistics			
- Autonomous trucking and delivery - Traffic control and reduced congestion - Enhanced security	Automated picking in warehouses	Traffic control	Autonomous trucking and delivery

Source: PwC (2017), Sizing the Prize: What's the real value of AI for your business and how can you capitalise?

- 6.8 Four key observations can be made from this very brief overview. First, as a set of ‘general purpose technologies’, **AI will have far-reaching impacts across virtually all sectors of the economy** and will become increasingly ‘mainstreamed’: of particular relevance to the other Themes within this Audit, the application of artificial intelligence will be fundamental to advances in healthcare and to the archiving and interpretation of complex material. Second, despite recent advances, **the potential for future applications is vast** – and is likely to lead to the development of new products and services that have not yet been imagined. Third, **the far-reaching implications of AI have led to a range of public concerns** relating to the ethics of the use of data and the employment consequences of sophisticated robotics. Addressing public concerns and ensuring widespread engagement are likely to be important factors in the future development of AI. Finally, given the potential gains from early adoption of artificial intelligence solutions, **global competition is fierce and this will have major implications for the future of the global economy**. For example, China accounted for some 48% of total equity funding to AI businesses in 2017 and is increasingly engaged in cross-border investments⁶⁰.

Potential economic impact and the business landscape

- 6.9 Recognising the far-reaching impacts of artificial intelligence, several recent reports have estimated substantial – although varying – economic benefits. For example, analysis by Accenture and Frontier Economics in 2017 estimated that the exploitation of artificial intelligence could add around £580 billion to UK GVA by 2035⁶¹.
- 6.10 Successive reports indicate both **challenges and opportunities for the UK** associated with the exploitation of AI. According to Jürgen Maier’s recent review of industrial digitalisation, the UK has “the strongest AI and machine learning market in Europe”, with over 200 SMEs (compared with 81 in Germany)⁶²; between 2010 and 2016, the total value of venture capital fundraisings for AI companies in the UK exceeded that of Germany and France combined⁶³. UK start-ups have also proved attractive for direct investment from the tech giants, in recognition of the long term potential of their AI technology. These include Google’s acquisition of the Knowledge Quarter’s DeepMind for \$650 million in 2014, as well as SwiftKey (by Microsoft, for \$250m) and Magic Pony (by Twitter for \$150m). However, despite these significant advantages at the ‘leading edge’ of technology, recent reports have highlighted the need to drive wider industrial adoption, to realise the benefits of some of the applications identified above⁶⁴.
- 6.11 Building on a review of the UK’s artificial intelligence capabilities by Professor Dame Wendy Hall (a City University alumna) and Jérôme Pesenti, the Government published the **AI Sector Deal** in April 2018. The Sector Deal sets out a goal of “*making the UK a global centre for AI and*

⁶⁰ CBInsights (2018), *State of AI 2018: Artificial intelligence trends reshaping industries and economies*, p.22 (https://www.cbinsights.com/reports/CB-Insights-State-AI-2018-Briefing.pdf?utm_campaign=state-of-ai-2018-02&utm_medium=email&hsenc=p2ANqtz-876m5gape7qNYINr0l-HpRDlrHS1F5YQqSYWfJT_YiQ37hMQqITBi4mWQfb7Fw0ewNZVWmPWvqPfOM-8ASIKhFDlxQ&hsmi=60733741&utm_content=60733741&utm_source=hs_automation&hsCtaTracking=7be068d3-4307-4d95-a2a2-d43ea8407ae4%7Ca7b69a6a-84c2-47f4-a5e9-91a14da18f65)

⁶¹ Mark Purdy and Paul Daugherty (2017), *Why artificial intelligence is the future of growth*, Accenture, p.20. The Accenture/ Frontier Economics study quotes an addition to GDP of \$814bn (converted to sterling at \$0.71 to the £, April 2018). Separately, PwC (2017) estimated an increase in UK GDP of £232bn to 2030 as a result of AI

⁶² *Made Smarter Review* (2017), p.29

⁶³ Professor Dame Wendy Hall and Jérôme Pesenti (2017), *Growing the artificial intelligence industry in the UK*, p.39, quoting analysis based on Pitchbook data. Note however that the UK still lags substantially behind the United States in terms of investment deals.

⁶⁴ *Made Smarter Review* (2017), p.29

data-driven innovation by investing in R&D, skills and regulatory innovation”, and contains specific measures relevant to the growth of data science in the Knowledge Quarter:

Box 6-1: The AI Sector Deal: Key measures

Measures announced by Government to support innovation in artificial intelligence include:

- Creating a £20 million GovTech Fund, supported by a GovTech Catalyst, to support tech businesses to provide innovative public service solutions and help to develop the growing ‘GovTech’ sector
- Investing a further £21 million in Tech City UK, as it evolves into Tech Nation
- Developing the Alan Turing Institute to become the “national academic institute for artificial intelligence and data science”
- Funding to support additional AI PhD places and increasing the availability of Tier 1 visas for ‘exceptional talent’ to ensure future AI expertise
- Development of a data ethics centre

Source: BEIS/ DCMS (2018), AI Sector Deal

Artificial intelligence and the London economy

6.12 The Mayor’s draft **Economic Development Strategy** describes London as “*one of the world’s leading hubs for digital technology, with particular strengths in specialist fields such as artificial intelligence, financial technology and digital health*”⁶⁵.

6.13 In this context, the Mayor’s office commissioned **The AI Growth Capital of Europe**, a review of London’s artificial intelligence capabilities in June 2018. Mapping of the city’s businesses identified 758 ‘artificial intelligence suppliers’, with strengths in AI related to the financial and professional services sectors and concentrations within the Knowledge Quarter (as well as in Shoreditch, Southwark, the City and Canary Wharf)⁶⁶. It also noted that the city’s AI businesses are “primarily at a nascent state of development”, with over 80% established since 2012; from a survey of AI businesses, ‘tolerance and diversity’, access to skills and talent, and access to clients were highlighted as particular favourable factors associated with location in the city⁶⁷.

6.14 In particular, the review emphasised that “London’s USP is demand”, with a strong concentration of ‘leading edge’ corporate consumers of technology (especially in areas such as financial services, law and the media) requiring innovation in new data science applications⁶⁸.

“It turns out that London is a much better place [to develop commercial applications for AI] than Silicon Valley because San Francisco is totally dominated by the technology industry. Our city is the total opposite – the centre of more industries than any other metropolis, from media and politics to fashion and advertising”

Rohan Silva
Evening Standard, April 2018

6.15 Following the review of London’s AI industry, **Smarter London Together** set out the Mayor’s ambition to develop London as “the smartest city in the world”, through investment in mobilising publicly-held data to support improved public services and opportunities for the development of new products utilising data science⁶⁹.

⁶⁵ Mayor of London (December 2017), *The Mayor’s Economic Development Strategy for London* (consultation draft), p.17 (<https://www.london.gov.uk/sites/default/files/economic-development-strategy-for-london-2017.pdf>)

⁶⁶ Specifically, the report identified the EC1, N1 and WC1 postcode areas as among ‘London’s top 10 locations for AI suppliers’. Mayor of London/ CognitionX (June 2018), *London: The AI Growth Capital of Europe*, p.32

⁶⁷ Ibid., p.44 based on the Mayor’s London AI Innovation Census, May 2018

⁶⁸ Technopolis’s analysis of ‘competitor/ comparator’ locations reflects this. In particular, while the emerging ‘Cyber Valley’ proposition in Germany is highly dominated by engineering and ‘Industry 4.0’ applications, and Boston is strongly focused on robotics, London maintains a strong presence in services, reflected in its data science business base.

⁶⁹ Mayor of London (June 2018), *Smarter London Together* (https://www.london.gov.uk/sites/default/files/smarter_london_together_v1.64_-_published.pdf)

Science and innovation assets in the Knowledge Quarter

University research strengths

- 6.16 The Knowledge Quarter has outstanding university strengths in relation to data science and the exploitation of artificial intelligence. In the field of computer science and informatics, University College London is the highest ranked university in the UK by grade point average and the second highest by research power. Both City University and Birkbeck also feature in the top 50 UK universities on both measures (with City performing strongly on research power).

Table 6-2: Research Excellence Framework: UK rankings in computer science and informatics

Institution	Institution rank	
	Research power	Grade point average
Birkbeck, University of London	42	41
City, University of London	22	43
University College London	2	1

Source: REF 2014

- 6.17 In addition, UCL is in the top ten institutions nationally (by research power and grade point average) in mathematics, with City featuring in the top 40.
- 6.18 Beyond these headlines, the universities in the Knowledge Quarter host several major digital science research centres.

Table 6-3: Selected data science research centres at universities in the Knowledge Quarter

Centre	Description
UCL Centre for Computational Statistics and Machine Learning (CSML)	Brings together expertise from Computer Science, Statistical Science and the Gatsby Computational Neuroscience Unit to research the scope for advances in machine learning in relation to a range of disciplines across the University
UCL Centre for Blockchain Technologies	Research hub which examines the impact of blockchain technologies ⁷⁰ on regulatory and technical systems and promotes the development of blockchain platforms
UCL Centre for Data Science	Develops new mathematical and statistical theory and quantitative and computational methods to help make sense of large, complex datasets
UCL Centre for Artificial Intelligence	Carries out foundational research in AI, creating new AI technologies and advising on the use of AI in science, industry and society
UCL Robotics	Cross-faculty initiative to develop a teaching and learning platform in robotics and autonomous systems, with applications in life sciences, healthcare, manufacturing and the creative industries
City University Research Centre for Machine Learning	Focuses on neural-symbolic computing and learning, reasoning and knowledge extraction from big data, with applications in software verification, visual intelligence and multimodal signal processing
City University Centre for Software Reliability	Conducts research into the dependability of systems, taking account of the safety, security and reliability of hardware, software and organisations

⁷⁰ **Blockchain** is a 'digital ledger that "provides a secure way of making and recording transactions, agreements and contracts", enabling fraudulent activity to be more easily spotted, without the need for intermediaries. The most well-known use so far is in the Bitcoin virtual currency, although there is potential for a much wider range of applications, including (for example) in the management of electronic medical records. *The Guardian* (January 2017), 'Blockchain: What is it and what does it mean for development?' (<https://www.theguardian.com/global-development-professionals-network/2017/jan/17/blockchain-digital-technology-development-money>)

Centre	Description
City University Centre for Adaptive Computing Systems (CeNACS)	Conducts research into the engineering of distributive and non-centralised systems, including control structures and algorithms to preserve quality and security
City University Centre for Human-Computer Interaction Design	Focuses on the relationship between people and innovative technology, with the aim of creating more useful and usable systems
Birkbeck Institute for Data Analytics (BIDA)	Develops interdisciplinary research in data analytics and data science, focused on the 'convergence' of data from different domains and academic disciplines

Source: UCL, City University, Birkbeck

6.19 As this brief overview illustrates, **data science research is highly multidisciplinary**. All of the research centres above combine expertise in computer science and mathematics with a range of other academic disciplines. These relate both to the fundamental nature of data science research and the importance of (for example) neuroscience to the concept of machine learning, and to the very wide range of subject areas that will be impacted by advances in data science.

6.20 This is highlighted by a number of additional research centres that apply expertise in data science with the wider research strengths of the KQ institutions. These include the other themes of this Audit: in respect of **health and life sciences** for example, key research centres include the UCL **Institute of Digital Health**; **CoMPLEX** (UCL's centre for interdisciplinary research at the interface between data science and medical and life sciences) and UCL's **Institute of Health Informatics**. Looking more closely at KQ universities' broader research specialisms include:

- **Cass Business School** at City University (the UK's fourth highest ranked business school⁷¹) hosts the **Digital Leadership Research Centre**, which investigates the implications for organisations of digital transformation, including cyber resilience and the effects of digital technology on firm structure
- There is a concentration of expertise at UCL relating to the impact of data science on the **urban and built environment**. This includes the **Centre for Advanced Spatial Analytics**, focused on the concept of 'smart cities' and the **Space Syntax Laboratory**, which develops new ways of designing buildings and systems:

Box 6-2: Space syntax: Using data science to transform the environment

UCL is the UK's highest ranked institution by research power in architecture and the built environment⁷². The University's **Bartlett School of Architecture** originated the architectural research discipline of 'space syntax', which studies the effect of spatial design on the "social, organisational and economic performance of buildings and urban areas".

In practical terms, the Bartlett School's Space Syntax Lab works on integrating computational approaches into the design process, using virtual reality and augmented reality to design, build and operate buildings and urban areas. As part of this, the Space Syntax Lab incorporates the VR Centre for the Built Environment.

The space-based modelling approach pioneered at the Space Syntax Lab has been commercialised through **Space Syntax Ltd**, a UCL spin-out which remains based in the Knowledge Quarter (just off Grays Inn Road) with offices in Europe, the US and Far East, and a continuing relationship with the Space Syntax Lab.

Source: UCL; Space Syntax Ltd

⁷¹ FT European Business School ranking, 2017

⁷² REF 2014

Box 6-3: Artificial intelligence, big data and health

At City, University of London, the Crabb Lab, led by Professor David Crabb of the Division of Optometry and Visual Science, is using very large datasets to improve glaucoma treatments. Using machine learning and data science techniques, the Lab processes images from over 25 million data points to tailor treatment to the individual. This has been supported with a significant grant from the Wellcome Trust – itself a KQ institution – and from Novartis to explore the potential for the use of the Crabb Lab's techniques in improving treatments for age-related macular degeneration.

Source: City, University of London

Non-university institutions

6.21 In addition to its universities, the Knowledge Quarter contains major research assets. These include the **Alan Turing Institute**, the national institute for data science, based at the British Library. The Institute was established as a partnership between five universities (UCL, Cambridge, Oxford, Edinburgh and Warwick) and the EPSRC in 2015, and brings together researchers in mathematics, statistics, computer science, data ethics, software engineering, machine learning and AI, with a focus on the development of solutions to industrial challenges. The Institute's key research programmes include⁷³:

- **'Data science at scale'**, developing advanced algorithms in partnership with Intel
- **'Data-centric engineering'**, addressing challenges such as the resilience and monitoring of complex infrastructure (for example through the development of predictive maintenance in transport and energy systems), developed in partnership with Lloyds Register
- **Economic data science**, in conjunction with HSBC, investigating (*inter alia*) the use of machine learning in economic modelling and new ways of measuring work
- **Defence and security**, linked with Dstl and Joint Forces Command, researching the integration of information systems to improve cybersecurity and analysis to respond to complex urban security threats.

6.22 Following the recommendations of the Hall and Pesenti report (quoted above), the Institute was formally designated as the **UK's national research centre for artificial intelligence** in November 2017. Moving beyond the technical possibilities of data science, the Alan Turing Institute recently announced the establishment of the new **Ada Lovelace Institute**, focused on research into the ethical challenges presented by the application of data and algorithms, and addressing the increasingly salient issue of data governance⁷⁴.

⁷³ Alan Turing Institute, www.turing.ac.uk

⁷⁴ Alan Turing Institute: <https://www.turing.ac.uk/media/news/turing-partners-nuffield-foundation-announce-new-5-million-ada-lovelace-institute-examine-profound-ethical-social-issues-arising-use-data-algorithms-artificial/>

- 6.23 While the Turing is headquartered in the Knowledge Quarter, its reach is national, with academics associated with the Institute based within its founding partner universities and other institutions: for example, the data science programme developed with Intel is largely delivered from Edinburgh. The Turing Institute's reach has also recently expanded as additional universities have joined the consortium. However, the Institute's wider programme of 'open' lectures, workshops and symposia is mainly focused on the British Library base, potentially offering networking and engagement opportunities for businesses and other institutions located in the area.

Box 6-4: The Alan Turing Institute

A relatively new addition to the Knowledge Quarter's institutional landscape, The Alan Turing Institute opened its new research space at the British Library in October 2016. It was created by five founding universities (UCL, Cambridge, Edinburgh, Oxford and Warwick) and the EPSRC in 2015 as the national centre for data science. Following a House of Lords recommendation earlier this year, the Turing's national remit was extended from data science to also explicitly encompass artificial intelligence. In 2017/18, a further eight universities – from across the UK – announced that they would join⁷⁵. The Institute currently has over 250 researchers and this is set to grow further as the new universities are assimilated.

With a mission to *"make great leaps in data science and artificial intelligence research in order to change the world for the better"*, the Institute is explicitly cross-disciplinary, engaging mathematicians, computer scientists, social scientists and other disciplines to apply theoretical advances to real-world problems. At the heart of the Institute's mission is a commitment to **collaborative research** alongside partners in the private, Government and third sectors. The Institute has published eight challenges to direct its research, covering areas including health, government, security engineering, computing technology, finance, algorithmic decision-making and science and humanities. It runs major research programmes with strategic partners including the Lloyd's Register Foundation, Intel, HSBC and UK Government (GCHQ and MOD).

The Turing has strong ties with the Knowledge Quarter, and with the other themes of this SIA. For example, the Institute recently entered into a partnership with the research hospital UCLH to harness the power of data science and artificial intelligence to support clinical decision-making; it is also working with the British Library to explore how to manage the Library's digital assets and open up access to its collections. However, as a national institution, the Turing's 'footprint' extends across the UK: for example, the current partnership with Intel involves the creation of a dedicated research team at the Institute's facilities in Edinburgh; while the Institute's partnership with the Office for National Statistics brings the expertise of Turing researchers to work with the new ONS Data Science Campus in Newport. The Turing is developing plans to expand its international reach.

Beyond its strategic partnerships, the Institute has entered into collaborative research partnerships and supported Data Study Groups (week-long collaborative hackathons) with several organisations, including the Cystic Fibrosis Trust, National Grid, Siemens, Shell and Scottish Enterprise. In partnership with the data-driven investment firm Winton, it has also provided mentoring to five AI start-ups, two of which (Cognitiv+ and Alterest) are located just inside the Borough of Islington.

In addition to collaborative research, the Turing offers the opportunity for **training** for researchers. The Turing Doctoral Scheme enables PhD candidates to apply to undertake their research at the Turing, linked with a programme of 'enrichment', in which students already undertaking a PhD can spend one year at the Institute learning about data science and AI. In the Institute's first academic year, over 300 students applied to study at the Turing, and the Institute is exploring how to expand its training mission.

Finally, an important aspect of the Turing's work is in shaping the 'public conversation' in relation to data science and AI. Each year, approximately 5,000 people attend public lectures and events at the Institute, with the majority of events live streamed to a wider audience or posted on YouTube, while the Institute has also prepared policy papers on data governance and worked with the Nuffield Foundation and other partners to launch the **Ada Lovelace Institute** which will explore issues concerned with the ethics of data.

Looking to the future, a mid term review will be conducted by the EPSRC to assess the Institute's impact, and the Institute plans to develop new ways in which businesses (and the public and third sectors) can access its expertise and resources.

Source: Interview with Nicolas Guernion (Director of Partnerships, Alan Turing Institute); Alan Turing Institute Annual Report 2016/17; Alan Turing Institute (www.turing.ac.uk)

⁷⁵ These are: Birmingham, Bristol, Exeter, Leeds, Manchester, Newcastle, Queen Mary, Southampton

- 6.24 The Knowledge Quarter also hosts the **Data Science Section of the Royal Statistical Society**, located near Old Street. Established in 2017, the Data Science Section acts as a professional body for data scientists in the UK, with a remit to support knowledge exchange and recruitment into the profession
- 6.25 Two Government-backed institutions of national significance are based within the Knowledge Quarter. The **Digital Catapult** is a technology and innovation centre which aims to drive the early adoption of advanced digital technologies in industry, particularly the manufacturing and creative sectors. Within the Knowledge Quarter, the Digital Catapult operates a Digital Catapult Centre from its headquarters on Euston Road (the first of a network of four Digital Catapult Centres to be established nationally). In addition to the Digital Catapult, the Knowledge Quarter is also home to the **Future Cities Catapult**, which seeks to support innovation in urban mobility, infrastructure and health. The Future Cities Catapult also hosts the Urban Innovation Centre in Clerkenwell, offering data lab and co-working spaces to innovative businesses.
- 6.26 Adjacent to the Knowledge Quarter, **Tech Nation** (created in 2018 from the merger of Tech City UK and Tech North) is based off Old Street, and – in its earlier incarnation as Tech City – was established to promote the development of the then-emerging ‘Silicon Roundabout’ tech cluster. From those early days in 2011, Tech Nation now has a broader role in championing business opportunities and investment (for example through the publication of the annual *Tech Nation* reports) and in running programmes to assist ‘tech’ businesses in starting and scaling up.
- 6.27 There is, therefore, an extensive concentration of non-university research, translational and support assets within the Knowledge Quarter. Following this brief overview, two observations are worth making. First, **all of the institutions referred to above have a ‘national’ remit**, and, in part, their location in the Knowledge Quarter is a function of London’s role as a capital city. However, they are also locally accessible: for example the Turing Institute’s London base may be the core of a national organisation, but it also offers a route to engagement locally. Second, **the ‘formal’ boundaries of this Science and Innovation Audit somewhat underplay the extent of the local institutional architecture**. For example, Tech UK (the industry representative body) and the Open Data Institute (an independent data research body) are located just outside the two boroughs on which we are focused – but in a dense and well-connected city, they are equally accessible to the rest of the Knowledge Quarter.

The data science business base: Commercial strengths and capacities

- 6.28 **The Knowledge Quarter’s institutional assets are both *complemented by and connected with* a substantial stock of businesses engaged in the exploitation of data science.** The following paragraphs consider: first, the data science businesses that are based in the Knowledge Quarter; second, businesses that have roots in the Knowledge Quarter (for example as university spin-outs), even though they may now be based elsewhere; and third, the wider business networks that exist locally.

Data science businesses in the Knowledge Quarter

- 6.29 It is hard to define ‘data science’ businesses using standard industrial classifications: the innovative exploitation of data science is taking place in firms in many sectors, as well as in those categorised within computing and information technology. However, a rough estimate based on Office for National Statistics data suggests that there are around 5,000 ‘data science’ businesses within the boroughs of Camden and Islington – around a third of all data science businesses in Central London⁷⁶.
- 6.30 **Alphabet**, the parent company of Google, is perhaps the most prominent data science business in the Knowledge Quarter, employing around 1,000 engineers, particularly in the development of Google’s Android, voice search and Google Play products, with planning permission granted in 2017 for a new headquarters at King’s Cross. Evidence provided to this Audit by Google UK highlighted the “*ability to attract top engineers from around the world to London*” as important to the firm’s presence locally, alongside the UK’s university strengths in computer science⁷⁷.
- 6.31 Google is also a significant investor in locally-grown AI firms, acquiring DeepMind in 2014 (see case study below), while GV, its venture capital arm, has a substantial programme of investment in growing tech businesses globally. This reflects an approach taken by all the large tech corporates: Microsoft’s M12 investment fund has, for example, recently invested in **Hazy AI**, a UCL spin-out which anonymises customer data⁷⁸.
- 6.32 More broadly, the Hall and Pesenti report analyses the geographical distribution of AI companies in the UK, highlighting (unsurprisingly) a very strong concentration in London. In particular the report quotes the UK ‘Top 50’ list prepared by Sonovate: some 80% of businesses listed are London-based. Looking in more detail, **11 of the UK’s ‘top 50’ artificial intelligence businesses are located in the boroughs of Camden and Islington**, particularly around Farringdon/ City Road/ Old Street, at the point where the Knowledge Quarter and Shoreditch meet. Table 6-4 provides a brief summary:

Table 6-4: UK ‘top 50’ artificial intelligence businesses in the Knowledge Quarter

Business	Location	Business activity
BenevolentAI	Euston, NW1	Linking AI and medical research (see case study)
Clinithink	Shoreditch, N1	Data analytics in healthcare applications ⁷⁹
Codec	Old Street, EC1	AI for content marketing
DeepMind	King’s Cross, N1	Developing learning algorithms (see case study)
Emotech	Bloomsbury, WC1	Personal robotics
Improbable	Farringdon, EC1	Simulated environments
Jukedeck	Moorgate, EC2	AI to develop original music
Media Gamma	Clerkenwell, EC1	Advertising technology
Ravelin	Clerkenwell, EC1	Anti-fraud protection
Skim.it	City Road, EC1	Text abstracts and summaries
Tractable	Clerkenwell, EC1	Deep learning algorithms

Source: Sonovate (2017), ‘The 50 hottest UK AI companies’, SQW

⁷⁶ SQW analysis based on 2017 UK Business Count data, using a SIC code based sector definition. ‘Central London’ is defined as Camden, City of London, Islington, Kensington and Chelsea, Lambeth, Southwark and Westminster

⁷⁷ Google UK, evidence provided to the KQ SIA, March 2018

⁷⁸ Hazy AI (www.hazy.com); M12 (<https://m12.vc/companies/>)

⁷⁹ Note that Clinithink’s main UK office base is now based in Bridgend

- 6.33 Of these businesses, all but one have been established since 2010, with some set up as recently as 2015, indicating the pace of change in the industry. The list also illustrates the range of applications that emerging AI businesses are engaged in developing, extending from life sciences to financial services to engineering. The experience of **Benevolent AI** highlights how demand for artificial intelligence solutions is driven by industry need, and how technology developed to apply in one sector (in this case life sciences) can have wider application:

Box 6-5: Applying data science to life sciences: Benevolent AI

Based in Euston, Benevolent AI is one of the UK's leading artificial intelligence innovators.

The firm was founded in 2013 by Ken Mulvany following the sale of Proximagen, a successful biotech business that Ken founded. Recognising the mismatch between the growing volume of available data and our ability to process it, BenevolentAI was established to build and apply artificial intelligence to turn highly fragmented unstructured and structured information into new insight and usable knowledge.

BenevolentAI currently operates two distinct business units; 'BenevolentBio' which applies BenevolentAI's technology in human health and the exploration of further bioscience applications and, 'BenevolentTech' which refines and develops the company's technology and replicates its initial success across wider applications and industries.

BenevolentTech is developing an advanced artificial intelligence platform that helps scientists make new discoveries. The technology probes 'hidden' scientific knowledge and deduces what 'should' be known based on what 'is' already known. The platform, and its associated unique systems and designed AI tools, generates usable knowledge from vast volumes of unstructured information in scientific papers, patents, clinical trial information and from a large number of structured data sets.

The technology understands information by employing an array of proprietary deep learning linguistic models and algorithms to analyse and understand context; then reasons, learns, explores, creates and translates what it has learnt to produce unique hypotheses. The platform is unlike a typical computing system, in that it is not programmed; rather it continuously learns on its own from interactions with experts.

This enables previously impossible scientific discoveries by finding connections that would otherwise have been missed. This has been used to automate the extraction of biological knowledge, undertake predictive and generative biochemistry, and advance better therapeutic molecules.

BenevolentBio is focussed on applying the company's technology in the bioscience industries, with an initial focus on human health. So far, BenevolentAI has developed a significant pipeline of drug candidate programmes ranging from early-stage discovery assets to Phase IIb clinical development assets and is working with major pharmaceutical groups to licence compounds and develop drugs. The company also works closely with charities and other funders, especially in rare disease areas.

In April 2018, BenevolentAI secured a further \$115 million from investors to scale its drug development and artificial intelligence platform, bringing the firm's total value to over \$2 billion.

Source: BenevolentAI (www.benevolent.ai); Bloomberg (<https://www.bloomberg.com/news/articles/2018-04-19/ai-powered-drug-developer-hits-2-billion-valuation-plans-hires>)

- 6.34 Elsewhere in the drug discovery world – linked closely to the life sciences theme of this Audit – **GTN** was co-founded by Vid Stojević, a UCL quantum physicist, and has developed software using machine learning techniques to discover molecules that would otherwise be unobserved. Like Benevolent AI, GTN is making use of artificial intelligence to develop new drugs which would be too costly and risky to bring forward using other methods. Within the Knowledge Quarter GTN (based on City Road) also has a research partnership with the Crick Institute⁸⁰.
- 6.35 In **financial services** – an area of relative strength in AI for London, according to the Mayor's recent review – there is some evidence of links between businesses that are using technology to disrupt existing business models. For example, **Azimo**, the digital international money

⁸⁰ GTN (<http://gtm.ai/index.html>)

transfer service, was established in Islington in 2012; subsequently, Azimo founders Ricky Knox and Michael Kent launched **Tandem** (based in King's Cross), an app-based challenger bank with investment from eVentures and the founder of eBay. Elsewhere, the Knowledge Quarter also hosts the payments technology business **GoCardless** (Islington) and the peer-to-peer lender **Zopa** (Farringdon).

- 6.36 Across sectors, efforts are also being made to support greater interaction between data science businesses in the Knowledge Quarter. For example, Mindstream AI hosts regular 'Deeptech Monday' mixers at King's Cross, bringing together data scientists, academics, venture capital and others to support discussions on artificial intelligence and its commercial application.⁸¹

Business links with the knowledge base

- 6.37 There is evidence of strong connections between the Knowledge Quarter's research base and the growth of data science businesses. One of the best-known UCL spin-outs is **DeepMind**, established in 2010 and sold to Google for \$400 million four years later. DeepMind is particularly strongly rooted in the Knowledge Quarter through its relationship with UCL:

Box 6-6: DeepMind's Knowledge Quarter connections

Google DeepMind is a world leader in artificial intelligence research, specialising in machine learning, advanced algorithms and systems neuroscience. It has developed a deep learning system which learns from experience without being pre-programmed: testing on computer games has demonstrated that DeepMind AI is already able to play chess and other complex games with 'superhuman' abilities. Founded in 2010, DeepMind was acquired by Google in 2014 and has also secured substantial venture capital and entrepreneurial investment, including from Elon Musk.

Links with UCL and the Knowledge Quarter...

The start-up was founded in 2010 by Damis Hassabis, Shane Legg and Mustafa Suleyman: Hassabis and Legg met while both were working at UCL's Gatsby Computational Neuroscience Unit, while all three are now UCL Honorary Fellows. UCL continues to have very strong links with DeepMind: Thore Graepel, UCL's Professor of Computer Science and Chair of Machine Learning, is the research lead at DeepMind, while UCL forms an important talent base for DeepMind staff

... and with the wider community

DeepMind co-founder Mustafa Suleyman is also co-chair of the Partnership in AI to Benefit People and Society, an open platform for discussion and engagement about AI and its influence on society. Maintaining the firm's close links with UCL, DeepMind also sponsors scholarships for students through the Windsor Fellowship Scheme, which aims to ensure that under-represented groups have access to post-graduate studies in a range of computer science and data science disciplines.

In June 2018, Demis Hassabis was appointed as an advisor to the Government's Office for Artificial Intelligence, a new body established to oversee implementation of the UK's AI strategy and to promote industry-to-industry collaboration.

Source: UCL

- 6.38 While DeepMind is particularly well known, there is a significant stock of other data science businesses in the Knowledge Quarter with strong links to the university base, many of which have been actively supported by the universities' commercialisation and investment arms. UCL Business plc (UCLB), the commercialisation company of UCL and its partner NHS Trusts, started with a focus on life sciences, but has since expanded into supporting the expansion of data science businesses with origins in the university. These include several firms based

⁸¹ Mindstream AI; evidence provided to the Knowledge Quarter SIA.

within the Knowledge Quarter, including **Bloomsbury AI**, a computer science company working at the “frontier of code which writes code”; **Correvate**, which develops software for use in Building Information Management (BIM) systems; **Quantemol**, a software spin-out from the Department of Physics and Astronomy, based at Angel; **Media Gamma**, which predicts online user behaviour for marketing purposes⁸². **Satalia**, based at Rocket Space in Islington, was founded in 2007, and uses artificial intelligence to optimise scheduling and infrastructure planning: its founder, Daniel Hulme, also maintains a computer science teaching position at UCL. Both Media Gamma and Bloomsbury AI have also received investment through the **UCL Technology Fund**, an investment fund managed in conjunction with UCLB.

Box 6-7: Supporting academic spin-outs: UCLB

UCLB is the commercialisation company of UCL and its partner NHS Trusts, aiming to provide a link between university academics, entrepreneurs and investors. Established in 2006, UCLB grew from an earlier technology transfer company, and offers support to UCL innovators in creating new businesses, protecting IP, registering patents and identifying potential investors and partners. UCLB also co-manages (with Albion Capital) the UCL Technology Fund, a £53.3 million investment fund supporting licensing projects and spinout companies.

While UCLB has long had a focus on life science spinouts, reflecting UCL’s strengths in medical research, it has since developed a significant artificial intelligence portfolio, including the businesses highlighted above. The portfolio has grown substantially – currently there are 67 active spinouts – but the real challenge is in enabling businesses to effectively scale up. Access to finance appears to be less of an issue than it was at the time of the financial crisis – especially for firms pioneering new applications of artificial intelligence, for which there is a very active commercial market. However, access to space is challenging in a dense urban area – especially for firms moving beyond smaller-scale managed workspace

Source: UCLB: website analysis and discussion

Box 6-8: Supporting university entrepreneurship: The Cass Entrepreneurship Fund

At City, University of London, the Cass Entrepreneurship Fund was established in 2016 with the support of Sir Peter Cullum CBE, a Cass Business School alumnus and philanthropist. The Fund aims to create a ‘hub’ for growing businesses and entrepreneurs, including those that have emerged from the Cass network and beyond. As well as making equity investments of up to £1 million in high-potential businesses, it also supports access to flexible working space and mentoring support from the Entrepreneurship Fund team.

Businesses supported by the Fund are quite widely distributed geographically, reflecting the role of the Cass Business School as a nationally significant centre for executive education. While not explicitly focused on data science, the Fund has invested in AI businesses, including NorthRow, a risk scoring platform able to handle complex fraud detection, and Alva, which analyses multiple, complex publicly available content and which has grown from a Cass alumni start-up to a firm worth several million pounds based in London and New York.

Source: City, University of London

Local science and innovation talent

- 6.39 The AI Innovation Census commissioned by the Mayor of London highlighted access to skills and talent as the factor most often cited by tech businesses in choosing a city in which to locate. Overall, respondents were broadly positive about London as a place in which to attract talent, in the context of a small and competitive global pool⁸³.
- 6.40 In the Knowledge Quarter, **the universities are important generators of talent**. The analysis above has highlighted the extent to which the universities are able to commercialise academic expertise – and in the case of firms such as DeepMind, retain strong links with the

⁸² UCL, UCLB

⁸³ Mayor of London/ CognitionX (June 2018), *London: The AI Growth Capital of Europe*, pp.46-47

academic research base and in developing the 'next generation' of computer scientists. However, the universities are also important teaching institutions for a wider talent pool. In June 2018, some 33 taught postgraduate computer science courses were on offer in the KQ's universities⁸⁴, including specialist courses in machine learning, cyber security and robotics and computation. However, at the heart of the development of artificial intelligence is the extent to which understanding and capabilities cross disciplinary boundaries: AI is *not* just about computer science. In this context, the KQ's universities offer real strength in delivering cross-disciplinary teaching in parallel with their research expertise – for example in neuroscience at UCL and human-computer interaction at City.

- 6.41 The Knowledge Quarter is also successful in **attracting talent**, both to its academic and commercial organisations. In part, this is a function of London's role as a world city and the range of opportunities – in a variety of fields – that are available here, and the KQ has proved attractive as a location to work and invest, as the example below illustrates:

Box 6-9: Attracting and growing international entrepreneurship: MishiPay

Mustafa Khanwala studied for an MSc in Engineering with Finance at UCL, and was sponsored by the University through the Tier 1 (Graduate Entrepreneur) visa process. This enables international students to stay in the UK for up to two years to grow a promising business.

While at UCL, Mustafa and co-founder Tanvi Bhardwaj established MishiPay, a 'smart shopping technology' which uses theft-proof technology to enable customers to scan, pay and leave, avoiding queues. In December 2017, MishiPay raised £1.65 million in seed funding to help grow the business.

Source: TechCrunch, <https://techcrunch.com/2017/12/08/mishipay/>; London First, <http://www.londonfirst.co.uk/wp-content/uploads/2018/02/MishiPay.pdf>

- 6.42 The extent to which firms such as Media Gamma and Bloomsbury AI have chosen to remain in the KQ, despite relatively high costs, demonstrates the wider importance of access to the knowledge base, networks and central location that the Knowledge Quarter offers. Reflecting the challenges identified by UCLB in securing access to the right space in which businesses can grow, efforts have been made by the universities, working with the local authorities, to increase the supply of small business space – for example, through UCL's **Base KX** facility on Camley Street, which currently accommodates 27 mostly digital tech businesses, all of which are led by UCL student entrepreneurs⁸⁵.

- 6.43 However, while access to talent is seen as one of London's core strengths, **risks have been highlighted by businesses**, given high international competition in the market for advanced engineering skills, high housing costs, potential restrictions on European labour movement and the efforts that competing cities in Europe are making in attracting international talent and inward investment.

"My big problem is that a lot of young people who are tech workers don't actually want to live in the UK anymore, so we have got people drifting towards places like Berlin [and] Barcelona... There are not an awful lot of reasons if you are a young tech millennial to be in London, with the exception of it is where the work is, and if the work drifts away, you might see quite a big impact"

Michael Kent, Azimo
Financial Times, April 2018

- 6.44 This is recognised within the AI Sector Deal, which announced (among other measures) industry investment in a new Masters degree

⁸⁴ 8 at Birkbeck, 8 at City, University of London and 17 at UCL

⁸⁵ UCL

programme, funding for additional PhD places and the establishment of a new Turing Fellowship “to keep the best and brightest AI researchers in the UK”⁸⁶.

National and international engagement

- 6.45 For some of the Knowledge Quarter’s data science assets, connections with the rest of the UK are centrally important. For example, the **Turing Institute** is explicitly set up as a collaborative institution, working with universities from across the UK, and the number of partner universities has expanded in recent years. Likewise, the Digital Catapult, based at King’s Cross aims to be a “multi-stakeholder UK-wide network of digital and physical facilities”, with additional centres in Brighton, Sunderland and Belfast, as well as partnerships with other institutions⁸⁷.
- 6.46 **Strong international connections** were frequently cited during consultation on this Audit as a key strength of the Knowledge Quarter. In addition to the labour market dimension set out above, these have three key dimensions.
- 6.47 First, there is significant **foreign direct investment** in data science. In 2016, London accounted for some 17% of all the FDI in tech businesses in Europe, according to the *EY Investment Monitor*, accounting for 63% of all inbound tech investments in the UK⁸⁸. Within the KQ, Google’s new campus at King’s Cross is a substantial investment of around £1 billion in total, accommodating some 7,000 staff when complete. Investment by the Silicon Valley tech giants in innovative businesses such as DeepMind also represents a considerable addition to UK FDI; while the majority of BenevolentAI’s latest \$115 million funding round was sourced from the United States.
- 6.48 Second, there are also **collaborations between data science businesses in the Knowledge Quarter and overseas academic institutions**. For example, UCL spinout and Rocket Space tenant Satalia has directly invested in the Institute of Mathematics at Klagenfurt University in Austria as part of a ‘strategic partnership’ to generate disruptive innovations in artificial intelligence and optimisation solutions⁸⁹.
- 6.49 Third, there examples of **data science businesses starting in the KQ and developing at locations outside London**. In a sector which remains relatively young, proximity to research expertise, technical talent and investment is important. However, as firms have matured, they have grown and created jobs elsewhere in the UK. For example, Thomson Screening, a City, University of London spin-out developing software screening solutions, now operates globally from its base in Hatfield.

Conclusions – and future potential

- 6.50 The Knowledge Quarter has impressive research and commercial assets in relation to data science. This has already led to the growth of some highly successful businesses, linked with the area’s university strengths, of which DeepMind is perhaps the most well-known. The pace of growth in artificial intelligence has led to significant investment from VC funds and the

⁸⁶ HM Government, *AI Sector Deal*

⁸⁷ Digital Catapult (<https://www.digicatapult.org.uk/regional-engagement>)

⁸⁸ EY (2017), <http://www.ey.com/uk/en/newsroom/news-releases/17-06-26-inbound-tech-investment-into-the-uk-reaches-ten-year-high>

⁸⁹ UCLB

major tech companies. The KQ's asset base has also been supplemented in recent years by substantial public investment in (for example) the Turing Institute.

- 6.51 Looking ahead, the *future potential* activity is significant. It will be important to ensure that links across the KQ's data science assets amount to more than the sum of their parts and that robust networks are in place to sustain and build on KQ's key commercial and institutional assets. However, the market for international talent in artificial intelligence is intensely competitive, and part of the KQ's success to date is down to its ability to attract and develop the capabilities of those who locate and invest here. Competition for talent will be an important driver of competitiveness across the board.

7. Links between Themes: Hypotheses revisited

Chapter Summary:

The Knowledge Quarter SIA was focused on three hypotheses. Looking across all three Themes, this chapter distils the evidence in relation to each. The evidence base is in part the “hard data” that informed the three Thematic chapters, but the analysis also draws on the qualitative findings from various surveys and workshops which were conducted as part of the SIA.

Overall, the evidence assembled through the SIA supports all three hypotheses, albeit it concludes that more could be achieved in the future.

- 7.1 Preceding chapters have demonstrated – in some detail – the scientific and knowledge-based strengths and innovation capacities that exist *within* each of the three Themes within the Knowledge Quarter. However, **the three hypotheses which shaped our Science and Innovation Audit were concerned fundamentally with links and synergies across (as well as within) the individual Themes; and beyond (as well as within) the geography of the Knowledge Quarter.** This chapter draws on a range of evidence gathered through the Audit to revisit the three hypotheses. It relies particularly on partners’ primary evidence gathering from workshops, surveys and bilateral discussions. It is therefore “softer” evidence than from other sources, but it provides an important insight into both the “the workings” of the Knowledge Quarter and their effect.

Hypothesis 1: That close proximity in an urban setting facilitates open innovation between knowledge-based organisations

- 7.2 The evidence gathered in the course of the SIA provided some evidence in support of this first hypothesis, albeit the hypothesis itself needs some unpacking.
- 7.3 In part at least, the hypothesis relates to whether – and to what extent – the area we are defining as the “Knowledge Quarter” has the attributes of an “innovation district”. These have been defined as “*geographic areas where leading-edge anchor institutions and companies cluster and connect with start-ups, business incubators, and accelerators*”. Beyond this, they “*embrace city-ness*” – and they constitute:

the ultimate mash up of entrepreneurs and educational institutions, start-ups and schools, mixed-use development and medical innovations, bike-sharing and bankable investments—all connected by transit, powered by clean energy, wired for digital technology, and fuelled by caffeine⁹⁰.

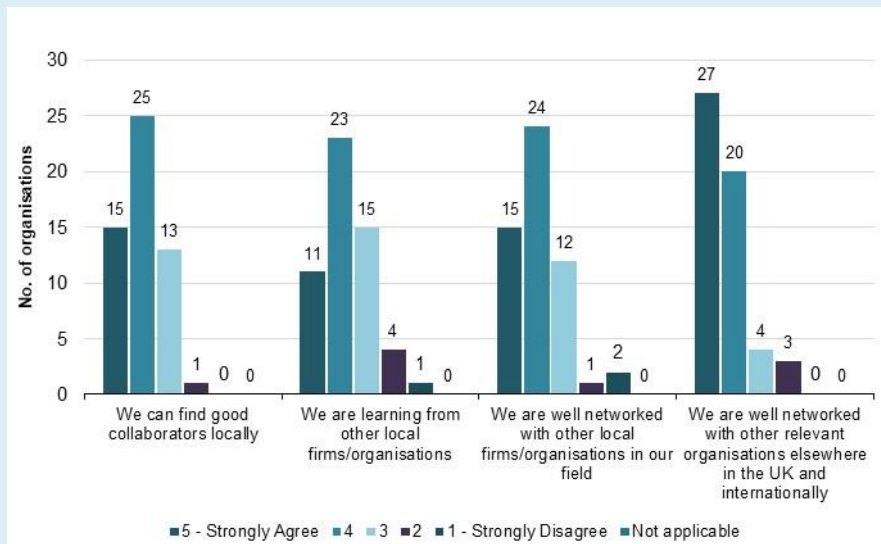
- 7.4 An online survey of businesses and organisations in the KQ undertaken as part of the SIA explored patterns of collaboration and networking. Key findings are summarised in Box 7-1.

⁹⁰ “The rise of innovation districts: a new geography of innovation in America” – paper by Bruce Katz and Julie Wagner, published by the Brookings Institute (2014)

Box 7-1: Key findings from a survey of knowledge-based organisations in Knowledge Quarter

- In total, the survey generated almost 60 responses
- From these, 34 organisations regularly work formally or informally with other organisations located in Camden and Islington, 17 organisations do so occasionally and three never do so. When broken down by organisation type, charities and the voluntary sector are most likely to be regularly working with other organisations in the KQ (12), followed by commercial businesses (7) and organisations that are university-related (7).
- Some 38% of organisations said they often work with local organisations with an interest in life sciences, 39% often work with local organisations with an interest in cultural, scientific and heritage collections and 30% often work with local organisations with an interest in data science. What was striking from the findings was the extent to which respondents associated themselves with more than one of the KQ SIA themes.
- From the survey, there were specific examples of collaboration within the KQ linked to the SIA Themes, including:
 - a Museum collaborating with Higher Education Institutions (HEIs) to plan and support courses for students using the Museum and its collections as inspiration
 - a research institution working with other research institutions on specific projects as well as forming a partnership with an innovation centre.
 - a research institution collaborating with one of the London Boroughs and other local community organisations for the purposes of promoting public engagement with science.
 - a commercial business collaborating with academics from HEIs and other commercial businesses.
 - a commercial business whose employees often act as mentors to local start-ups and other businesses.
- When probed, organisations within the KQ generally agreed that they could find good collaborators locally; they could learn from other local firms and organisations; and that they are well networked with other local firms and organisations in their field. However, the strongest agreement came with the statement: 'We are well networked with other relevant organisations elsewhere in the UK and internationally' which links in with Hypothesis 3. (See Figure below).

In relation to collaboration and networking – in what ways is your business/organisation helped by being located in this part of London?



Source: KQ SIQ online survey, number of responses = 54.

Source: KQ SIA esurvey

7.5 Overall, the survey found that most respondents considered that they could *find good collaborators* locally and most suggested good levels of local *networking*. The extent to which respondents agreed that there was substantial local *learning* – perhaps the closest proxy for

open innovation – was slightly lower. However, what was also striking was the extent to which respondents were *networked nationally and internationally*. Whilst “*being in this part of London*” afforded certain advantages in terms of local ties, it also clearly equipped respondents to build networks outside the capital, across the UK and internationally.

- 7.6 These issues were discussed in rather more detail at the Theme-specific workshops. Some of the principal findings are summarised in Box 7-2 below.

Box 7-2: Perspectives on the Knowledge Quarter as an “innovation district” from theme-specific workshops

From Life Sciences:

Attendees were asked to identify examples of innovation that have arisen because KQ is “something like” an innovation district. The following examples were given:

- “DeepMind collaboration with Moorfields Eye Hospital and UCL research”
- “application of AI and machine learning to life sciences challenges”
- “Benevolent AI and Bloomsbury AI spin outs / start-ups”
- “We have developed a relationship with DeepMind that has given young people the opportunity to learn from staff based there”

From Cultural Collections:

Attendees were asked if their organisation collaborated with other holders of cultural / scientific / heritage collections in the KQ area. 17 out of the 25 respondents responded positively

From Data Science:

KQ was seen as an “innovation district” because:

- it has a supporting eco-system
- it is surrounded by top universities with good networking opportunities
- there are innovative enterprises and innovative start-ups.

However, despite there being lots of innovation, there was some discussion about how much collaboration there was and whether the presence of the large anchor organisations is directly related to the number of start-ups / incubators / accelerators in London.

Source: KQ SIA stakeholder workshops

- 7.7 In addition to surveys and workshops, the SIA also benefitted from more in-depth interviews with businesses and other organisations from across all three Themes (and case study reports have been provided in preceding chapter); from a “Call for Evidence”; and from a review of literature. From all these different sources, the overarching observation was similar: in the main, organisations recognise fully – and understand the value of – “*the melee*” of the Knowledge Quarter and they are making their own locational choices in this context (see Box 7-3).

Box 7-3: New London Architecture – and the Institute of Physics

In May 2018, New London Architecture published a report “*Knowledge Capital: Making places for education, innovation and health*”. It explored how London needs to plan for the knowledge economy and make appropriate provision for collaboration and openness. It emphasised the physical and social/cultural dimensions of both processes.

NLA included a number of specific case studies. One of these related to the Institute of Physics (IOP), which is planning to relocate from Portland Place to Balfe Street (King’s Cross), at the heart of the Knowledge Quarter. The new building will incorporate education and exhibition facilities for the local community and schools, alongside function and start-up incubator space.

NLA explains that the new IOP headquarters will “link to the Knowledge Quarter, connecting with eight higher education institutions, 22 museums and galleries, 34 libraries and archives, 580 research centres, 3,000 scientists, 13,700 academics, 57,000 staff and 98,500 students within a one-mile radius” (page 50).

The Managing Director of IOP Enterprises explains the importance of both the new building and the location to IOP. She states: “The new headquarters for the IOP signals an open and community-driven direction for the organisation. The move to welcoming and public facing premises in the heart of London’s Knowledge Quarter in King’s Cross is a key part of our strategy to reach beyond our traditional networks and encourage the general public’s interest in physics” (page 50).

Source: Knowledge Capital – Making places for education, innovation and health, New London Architecture (NLA), May 2018

- 7.8 A final piece of evidence in this context has been gleaned from a survey that the KQ Partnership itself undertook in 2017. It is summarised below.

Box 7-4: Evidence gathered through the KQ Partnership’s own survey

The KQ’s 2017 report, *Unlocking Knowledge: Connections and Trust within the Knowledge Quarter*, included a survey of 235 staff at KQ member organisations. Almost half of them (48%) had worked in the KQ area for between one and five years.

Respondents were asked questions about a random selection of 20 KQ member organisations. Around half of respondents (51%) reported having a personal contact with at least one of the KQ partners, with 32% saying the relationship was strong enough for them to be able to ask their contact for advice or personal introductions. Just over half (53%) of respondents had more connections outside their sector than within it. In all, 69% of the total number of connections identified in this survey were across sectors. More than 85% of respondents said they would like to develop further contacts outside their sector. Many respondents noted, though, that building and maintaining such relationships took time and resources.

While it did not name them, the survey found that seven of the eight best-connected organisations in the KQ were large, non-profit organisations, each with relatively long histories in the KQ. The most-connected organisations tended to be relatively close to each other: **87.5% were within 250m of at least four other KQ organisations, while 60% of the least-connected were within 250m of only one of two other KQ organisations.**

The survey also showed that, while respondents were generally open to approaches from new contacts, receiving an email from someone with whom they had a personal link, or who was introduced by a colleague, made people especially likely to reply. The brand or reputation of the new contact’s organisation also had an impact on the chances of getting a positive response.

Source: *Unlocking Knowledge: Connections and Trust within the Knowledge Quarter*, Knowledge Quarter, 2017

- 7.9 From workshop discussions across all three Themes, the Knowledge Quarter was seen as an evolving endeavour: existing ties and networks are already reasonably strong, but in all cases, it was acknowledged that there is scope for significantly more and that much could be achieved through further animation and innovation.
- 7.10 Uppermost in relation to the constraints in this context were simply a lack of time (building relationships needs some level of investment and individuals are busy) together with – in some cases – a lack of physical provision and uncertainty in terms of where successful start-up businesses might need to move in order to grow. Further evidence is provided in Box 7-5 below.

Box 7-5: Barriers to collaboration identified through the KQ SIA “Call for Evidence”

From one of the HEIs in KQ: Many collaborations are informal and operate under the radar, not caught on any system and thus never reported on. However, barriers to more formal collaboration include bureaucracy/time and the different drivers behind businesses (which need to protect commercial interests) and academic research (which is often undertaken with public money and as a public good, with the concomitant desire to make the outcomes freely available)

From one of the (smaller) cultural collections in KQ: Some smaller organisations lack capacity and connections with researchers, developers, partners with whom we might work or who would benefit from what we can offer them whether it is content, data, knowledge, expertise or skills; and the need for greater experience in the commercial world, specific skills beyond our own field of expertise and knowledge of new developments, innovations, projects which benefit us.

Source: Knowledge Quarter SIA Call for Evidence

Hypothesis 2: That place-based ‘network brokers’ have an important role to play in catalysing relationships

7.11 From one of the cross-cutting workshops, an attendee commented:

“This place is an embarrassment of riches and an innovation district just in terms of proximity. What’s lacking is a deeper level of collaboration between organisations”⁹¹

7.12 In this context, the role of “network brokers” was recognised from the outset to be potentially important. The SIA’s second hypothesis focused specifically on the importance of place-based “network brokers” in the KQ in facilitating and catalysing relationships between different organisations.

7.13 Within KQ, “network brokers” are taking many different forms. Examples identified during the SIA workshops included the following:

- The **Institute of Physics (IoP)** is a membership organisation that represents people who have an interest in physics from academia, business, education and government. One of their objectives is to bring challenges from industry to academic partners to support open innovation.
- The **Design Council** is a charity that works across the built environment, business and public services to raise the profile of design. It provides design support services and training; delivers partner-funded programmes and runs campaigns to raise awareness about the value of design (including in economic terms).

7.14 In addition, there are many examples of **events** put on by KQ members to encourage “open innovation”. The **Digital Catapult** runs “The Pit Stop”. This brings together individual innovators, SMEs, start-ups and experts from key universities and research institutions to tackle a specific challenge in key business area through interactive sessions. The Pit Stop encourages participants to share knowledge and create valuable connections. The **Francis Crick Institute** puts on events, including exhibitions, seminars and conferences that actively encourage the exchange of ideas and multi-disciplinary research; while **City, University of London** runs events including open days, public lectures and conferences.

⁹¹ Cross-cutting SIA Workshop held on 5th April 2018

- 7.15 The Knowledge Quarter (Partnership – KQP) has also been an important innovation of recent years. A case study of it is provided at Box 7-6.

Box 7-6: Knowledge Quarter London Ltd

As of June 2018, Knowledge Quarter London Ltd is a formal partnership of 93 organisations located in a one-mile radius around King's Cross, Euston Road and Bloomsbury. Membership of Knowledge Quarter London Ltd is open to any organisation that “actively engage in the advancement and dissemination of knowledge.” Since its inception in 2014, it has welcomed 58 organisations as partners, including the Alan Turing Institute, City, University of London and Universal Music. Knowledge Quarter London Ltd was founded because organisations in close proximity felt they were not taking advantage of the potential for collaboration.

Knowledge Quarter London Ltd is a place-based partnership organisation with a governance structure whereby partners are able to direct its work. Partners pay into Knowledge Quarter London Ltd depending on their size with partnership fees ranging from £500 to £20,000. Through this structure, the Partnership is able to fund flagship projects in priority areas. It currently receives no Government funding and has a turnover of circa £200,000 with 2.4 FTE members of staff.

Knowledge Quarter London Ltd is unique in its ability to bring together local authorities, civic bodies, community groups, cultural and educational organisations and centres of science and research in order to create opportunities for knowledge exchange, shared services, collaboration and partnership through the creation of formal and informal networks. Knowledge Quarter London Ltd is also able through its structures to facilitate connections between partners and local community groups and to provide civic leadership in key areas. As a ‘network broker’ it circumvents a “tragedy of the commons” situation when it comes to the creation of place-based human capital and soft infrastructure.

Knowledge Quarter London Ltd's projects range from networking events between partners (for example an event looking at organisational models of knowledge commercialisation and the creation of a ‘knowledge bank’) to projects which develop skills in the local community. It ran a primary careers conference to raise aspiration in local school children. The one-day conference targeted students in year 5 (age 9–10) and in particular young people from vulnerable groups. The participants were from over 20 schools within Camden and Islington. After the conference each child was appointed as a careers champion and provided with a toolkit which they could use to arrange their own school-specific careers event, reaching even more children.

Research in 2017 found the value of the Knowledge Quarter network is its ability to reduce the ‘cost’ of collaboration; producing cultural and long-term value by creating trust between local actors. A survey of staff from KQ institutions found that more than 85% of respondents were interested in gaining personal contacts at more inter-sector than intra-sector KQ partners. This KQ provides a vehicle in which to enable multidisciplinary collaboration and networks and through its structure enable smaller organisations to build valuable networks with larger anchor institutions.

In terms of the impact of the KQP, it is clearly very early days and there has not been a formal evaluation. However, the esurvey completed in the course of the SIA did examine some of the issues. It found that 36 (of 54) respondents were members of KQP and of these, 32 agreed that being a member helped in “building networks and links with other firms and organisations in Camden and Islington”.

Source: Knowledge Quarter London Ltd

Hypothesis 3: That an exceptional concentration of scientific research and other knowledge-based organisations can effect innovation and economic growth elsewhere in the UK

- 7.16 The third hypothesis examines the extent to which the exceptional concentration of scientific, research and other knowledge-based organisations in the KQ has spill-over benefits in terms of innovation and economic growth elsewhere in the UK – including elsewhere in London.
- 7.17 Examples can be cited at different spatial scales. Within London itself, growing and deepening links to Stratford are part of the growth dynamic (see Box 7-7).

Box 7-7: Links to Queen Elizabeth Olympic Park, Stratford

The London 2012 Olympic/Paralympic Games provided a major catalyst for investment and regeneration in east London. However, the commitment to Stratford and the lower Lea Valley significantly predates London 2012; and post 2012, it has continued apace with a strengthening focus on knowledge and culture. In this context there are important and strengthening links to the KQ. These are providing an important route through which the area's science and knowledge-based assets can deliver additional impact.

There has been sustained interest in the Stratford area from institutions whose "home" in the KQ. Initially this came from Birkbeck, then from UCL (with the QEII Olympic Park (QEOP) vision drawing strongly on Jeremy Bentham/'Bloomsbury' model for place-making through widening participation). Thereafter (mid-late 2000s), wider institutions – notably London College of Fashion (LCF) and Loughborough University in London (LUIL) – expressed an interest in having a site on the QEOP.

Post-2012, the Mayoral vision was to attract cultural institutions to Stratford, including Sadder's Wells, V&A, Smithsonian. This was complemented by the formation of Here East: a re-purposing of the Olympics Broadcasting Centre as a digital technology cluster. LUIL (now based in Here East) also brought new dimensions, i.e. masters courses and research, notably around Advanced Propulsion Centre (Ford, McLaren etc.), leading to Ford Smart Mobility Centre and a test centre for UAVs (attracting interest from Toyota and Honda). Plexal, the former Press Centre for the 2012 Olympics, was re-modelled as innovation workspace. Elsewhere on the site, LCF is to create workspace for fashion industry, with potential links into robotics and movement (courtesy of UCL Engineering, LUIL). Other new tenants include: Financial Conduct Authority, working in partnership with GCHQ to create the new National Cybersecurity Centre (with links to the KQ's data science theme). The British Council is relocating to be alongside V&A and LCF. CRUK's move to QEOP will provide other tenants with exposure to life sciences.

Over the past 6-9 months, LLDC considers that QEOP has started to achieve scale and critical mass. Reflecting on the "journey" so far, the "Bloomsbury model" – which defined the KQ – has found a 21st century expression in QEOP and one that appears to be gaining momentum. This model is defined around a sense of being enterprising, entrepreneurial, dynamic, independent, emotional and edgy; in is grounded in "place" and is an antidote to 'large set-pieces'.

There is an intrinsic and deep-rooted connection to KQ. This should be a source of synergy going forward. LLDC – the organisation with overall responsibility for QEOP – is hoping that medical/health organisations will come out, to explore the ethnically diverse population of Stratford. If that were to happen, there could well be a 'Crick effect' in Stratford, based on growth in translational research in life sciences. In this latter regard, QEOP could offer expansion space especially for commercial biosciences (i.e. follow-on space), noting that this is in chronically short supply within the KQ itself. Excellent connections with KQ and more widely – by rail and air – make this the logical next step, both in securing QEOP's further development and in defining a mechanism for continuing to secure impacts from the KQ's world class science and knowledge assets.

Source: Based on discussions with LLDC as part of the SIA

7.18 Further afield, many different examples have been cited throughout this report. For example:

- In **Life Sciences**, there are strong and growing relationships with Stevenage Bioscience Catalyst in relation to processes of commercialisation. Benevolent AI – a company that leads the field internationally in AI-enabled drug development – is working with the Sheffield Institute of Translational Neuroscience (SITraN), part of the University of Sheffield, on finding treatments for ALS (motor neurone disease). It has recently established offices in Belgium and New York City, as well as acquiring laboratories just outside Cambridge (Babraham Research Campus) for its subsidiary, BenevolentBio. There are also many examples of small businesses that have developed within KQ and are seeking to grow elsewhere in the UK (e.g. see the case study of Jupiter Diagnostics). There are also numerous national and international research collaborations.
- In **Cultural Collections**, organisations like the British Library and British Museum are working extensively across the UK: as Chapter 5 highlights, the success of the British Library's Business and Intellectual Property Centre (BIPC) is now being reflected in the development of a national network of centres in other UK cities.

Internationally, organisations throughout the world can benefit from digitised collections with the transition to open access; while the KQ's cultural institutions have benefited extensively from international funding.

- In **Data Science**, the network developed by the Alan Turing Institute highlights the links between innovation in the Knowledge Quarter and the UK's leading universities beyond London. The KQ also hosts major institutions with an explicitly UK-wide remit (such as the Digital Catapult – which also has centres in Brighton, Sunderland and Belfast) and the Future Cities Catapult). National and international research collaborations are widespread, and the KQ helps to draw talent into the UK. Within London, the KQ's concentration of research-intensive data science also has a complementary relationship with the major tech cluster around Shoreditch.

8. Conclusions

Chapter Summary:

This Audit demonstrates that the Knowledge Quarter has world-class science and innovation capabilities in relation to life sciences, data science and cultural and heritage collections. The combination of scientific and knowledge-based strengths, commercial investment and an environment that attracts and retains talent ought to be seen as a significant asset for London and the UK. However, there is a risk that the KQ's unique combination of assets is not recognised and used as effectively as it could be.

In the light of this, KQ partners propose to develop a long term 'spatial plan' for the Knowledge Quarter ('KQ2050'). In the shorter term, we have also identified eight projects, which we will develop over the coming months to strengthen the KQ's science and innovation ecosystem.

- 8.1 At the start of the Science and Innovation Audit process, we set out a vision *"for the whole of the UK to benefit from the world-class expertise, facilities, collections and connectivity that characterise the Knowledge Quarter. By mobilising these assets, we plan to accelerate the pace of discovery science and innovation at national level, drive economic growth and help implement the new Industrial Strategy"*.
- 8.2 The Audit demonstrates the extent of the Knowledge Quarter's assets and capabilities. Based on this analysis, the KQ Steering Group has drawn up a list of priorities for the short, medium and long term. These aim to advance our vision, and respond to gaps and opportunities across the three Themes, through the lens of our three hypotheses.

Opportunities and risks

- 8.3 **The Knowledge Quarter is a world-class resource for London and the UK** in terms of innovation and research commercialisation. Some of the core 'building blocks' for this have been in place for many years, such as the KQ's universities and cultural institutions. However, much of its growth is more recent: for example, the transformation of the area around King's Cross, commercial investment by firms such as Google, and the advent of new institutions, such as The Francis Crick Institute. The success of the Knowledge Quarter today results from a combination of scientific and knowledge-based assets, market investment, an environment that attracts and retains talent, and long-term strategic planning.
- 8.4 Sustaining – and enhancing – this combination of assets is vitally important: they are both internationally significant and unique in the UK. However, there are risks ahead:
- first, **the technologies associated with the themes of this SIA are inherently dynamic – and so are the business models associated with them.** As the Knowledge Quarter accommodates global tech businesses, and as land values rise, there is a risk that the disruptive, knowledge-intensive businesses are priced out over time, and the link between commercial growth and the knowledge base fragments
 - second, **not all of the 'assets' of the Knowledge Quarter are being used as effectively as they should be.** There are substantial local pressures, particularly in relation to housing (availability and cost), many of the jobs generated in the KQ in recent years are 'low pay' in character, and there is a risk of increasing polarisation. Whilst Camden is ranked eleventh from top in the UK in terms of local authority areas

with the highest proportion of wealthy households, levels of deprivation in some parts of the borough (e.g. Somers Town) and in parts of Islington are similar to those in Hackney, Newham and Tower Hamlets, the local authority districts in the UK with the highest percentage of households living in poverty

- third, **the Knowledge Quarter remains largely invisible in the wider London and UK narrative**: while potentially a ‘premium brand’ which could be used to attract investment to the UK and drive links with other parts of the country, there is a risk that its combination of assets is ‘taken for granted’, and not exploited as fully as it might be.

The case for a long term strategy...

8.5 In this context, the SIA Steering Group recommends that we build on the evidence presented within this Audit to prepare a spatial plan for the KQ’s development, covering the next thirty years (**‘KQ 2050’**). We envisage that this will help to create a long-term vision for sustainable growth to which everyone – national and local government, local residents and commuters into the KQ – can subscribe. The purpose of KQ 2050 will be to:

- **give coherence and legibility to long-term aspirations for the area**, in which the possibilities surrounding science and knowledge are a central feature (in this respect, the Plan will resemble a ‘local industrial strategy’ for Camden and Islington, but with the benefit of a longer timeframe);
- **provide a ‘script’ that can be shared widely**, including internationally (“this is what the KQ will be like”);
- **build investor confidence** and, in the process, help both to accelerate the delivery of major schemes and ‘unlock’ key sites, including those that form part of the NHS estate;
- **provide a high-level framework within which infrastructure investment priorities might be meaningfully identified and advanced** – including housing (including accommodation to support the needs of temporary specialists within the knowledge base) and community infrastructure, as well as infrastructure to support the growth of the KQ’s universities and non-university research institutions; and
- **ensure that investment in the KQ delivers benefits to individuals and organisations more widely**, elsewhere in London and throughout the UK

8.6 If realised, the plan will provide a long-term framework for development processes within the KQ, and govern its relationship with strategic partners outside the KQ. It will exist within the framework of the London Plan and, whilst it will not have statutory planning status, it will influence the evolution of Local Plans in Camden and Islington.

... and for pragmatic action in the shorter term

8.7 Creating ‘KQ 2050’ will be the main follow-on activity for the Steering Group’s successor body over the next two years. In the shorter term and in support of this high-level commitment, Steering Group members will seek to advance more immediate projects within the KQ. Specifically, we will take forward the following:

- **Project 1: Creating a UK-wide Innovation Districts network**, recognising that there are shared opportunities and challenges, as well as shared substantive connections, and learning from – and contributing to – knowledge exchange and good practice [Lead institution: *Knowledge Quarter London Ltd*]
 - **Project 2: Building the ‘brand’ of the KQ**, in order to secure international profile and investment in innovation across the wider UK [Lead institutions: *RVC and Knowledge Quarter London Ltd.*]
 - **Project 3: Building stronger institutional ties** within and beyond the KQ, using a ‘network of network brokers’ to champion the benefits of **open innovation** [Lead institution: *Knowledge Quarter London Ltd.*]
 - **Project 4: Developing the start-up ecosystem in the KQ**, including: training for early-career researchers and small businesses in enterprise skills and market awareness (e.g. emerging sectoral trends and major disruptive innovations; innovation demand and supply), and providing enhanced access to finance. To do this at scale — and thereby make a real impact on the wider UK economy — will require leadership, funding and coordination between key organisations and individuals responsible for delivery of the training [Lead institutions: *UCL and City, University of London*]
 - **Project 5: ‘Unlocking’ the NHS estate**, working with colleagues in NHS Estates and the NHS Trusts to provide new wet-laboratory space in central London, utilising surplus NHS land [Lead institution: *Camden Council*]
 - **Project 6: Developing a Digital Content Innovation Hub**, drawing on the particular strengths and competencies of the major cultural organisations and taking forward a specific opportunity identified in the SIA [Lead institutions: *British Library*]
 - **Project 7: Developing ‘KQ visas’** to ensure that the KQ is able to attract international talent to invest, develop businesses and drive forward the knowledge base [Lead institution: *Knowledge Quarter London Ltd.*]
- 8.8 Outline, high level, business cases for each of these projects are provided in Annex A.
- 8.9 Over the next few months, KQ partners will develop these projects further, investigating their feasibility and identifying resources as appropriate. As we develop key interventions to support the Knowledge Quarter’s growth, we will maintain dialogue with those stakeholders engaged in the SIA process, including businesses and government at local, London and national level.
- 8.10 In view of the unique role that the KQ plays in the UK’s innovation landscape, we believe that both our aspirations for ‘KQ 2050’ and our shorter term projects present investment opportunities for central Government as well as for local partners, and we would welcome Government engagement on our journey. In particular, we will explore the potential for national funds (such as Strength in Places Fund) to co-finance project costs alongside local investment, and we will work with Government agencies (such as NHS Estates and the Home Office) to bring partners together and, if appropriate, investigate the opportunity to flex national policy.

Annex A: Proposed interventions in the short/medium term

Introduction

- A.1 As set out in Chapter 8, a series of measures have been identified as a result of the evidence presented in this Audit to support the future growth of the Knowledge Quarter as an internationally-significant concentration of science and innovation activity. Central to this will be the development of ‘**KQ 2050**’, a long term spatial plan. Knowledge Quarter partners will start work in taking this forward over the next few months.
- A.2 In the shorter term, this will be supplemented by seven projects, which aim to improve coordination among the institutions in the KQ, strengthen the operation of the innovation ecosystem and ensure that greater leverage is secured from the KQ’s ‘brand value’ as a leading innovation district. The seven projects that KQ partners seek to take forward are:
- **Project 1: Creating a UK-wide Innovation Districts network**
 - **Project 2: Building the brand of the Knowledge Quarter**
 - **Project 3: Building stronger institutional ties**
 - **Project 4: Developing the start-up ecosystem**
 - **Project 5: Unlocking the NHS estate**
 - **Project 6: Developing a Digital Content Innovation Hub**
 - **Project 7: Developing ‘Knowledge Quarter Visas’**

Project business cases

Project 1: Creating a UK-wide Innovation Districts Network

- A.3 The Knowledge Quarter is one of several ‘innovation districts’ emerging across the UK. Together, they are a national asset: given the strong links between institutions across the country, new investment in better connectivity, and complementary specialisms, there ought to be significant value in working more closely together at strategic level. Building on the outcomes of a series of Science and Innovation Audits across the UK, we will create a new network of innovation districts:

<i>Project outline</i>	
<i>Name of the project</i>	Creating a UK-wide Innovation Districts Network
<i>Summary of the project</i>	Self-defined and self-organised representative bodies for Innovation Districts are beginning to emerge across the UK. These bodies are capable of providing civic leadership, coordination from a range of organisations including central anchor institutions within key knowledge clusters. There is a need for Government to recognise the role of Innovation Districts and their member organisations in delivering the ambitions within national policy and strategic guidance documents such as the Industrial Strategy,

	Scottish Government Policy and the Northern Powerhouse Independent Review. This project proposes a national network which will accelerate the development of new Innovation Districts and amplify the impact of mature Districts.
<i>Who are the key partners?</i>	KQ London, KQ Liverpool, the Oxford Road Corridor, the Queen Elizabeth Olympic Park, Leeds and Glasgow Waterfront Innovation Districts Government departments including BEIS, DCMS, DCLG, DfE
Strategic case	
<i>What problem are you trying to solve – what is the rationale for intervention?</i>	The research on economic development and clustering has shifted from sector-specific clusters towards place-based innovation districts, with publications from organisations including Centre for London, Centre for Cities, SQW and the Brookings Institution highlighting this trend. A report for the Brookings Institution recognised a recent shift from innovation within traditional economic or industrial-type clusters to urban-centric innovation districts (Katz and Wagner, 2014). While a traditional cluster might focus on a particular theme or industry, innovation districts feature the co-location of innovation-intensive, leading edge institutions and companies of all sizes across a range of fields. The purpose of an innovation district is to facilitate access to other innovators, equipment and knowledge, and the integration of a region within a city emphasises the ability of its members to build networks, benefit from knowledge spillovers, and therefore increase value. A recent roundtable held by ARUP of UK Innovation Districts found that Innovation Districts could: - be the catalyst for encouraging Inclusive Growth, facilitating and promoting the importance that economic prosperity benefits all. - have a role in diversifying and simplifying access to capital assets and capital flows, giving them a unique approach to growth and investment. - through co-location and cross-collaboration, yield greater benefits for residents and beneficiaries of Innovation Districts. - help deliver the Industrial Strategy. Given alignments with the existing UK policy base, policy on Innovation Districts has potential to be developed further; in particular, given the positive examples of the extent to which it has been developed internationally, specifically, in the United States. There are a number of themes which could be explored within the industrial strategy which relate to or could be delivered by Innovation Districts. The actors within and impact of Innovation Districts cross over a number of UK Government departments including BEIS, DCMS, DCLG and DfE and there is an interest within the devolved nations. Given this, we recommend the formation of an innovation districts network with an accompanying research programme and a series of piloted projects across the UK.
<i>What are the links to current policy and what are the existing gaps in provision?</i>	There are already existing parallels between Innovation Districts and a number of current UK Government initiatives and strategies, suggesting they could support many of the Government's current aims and objectives. Innovation Districts align with the Government's productivity strategy, its wider devolution agenda, Science and Innovation audits, the smart specialisation strategy and the impact agenda within Universities. Indeed, Innovation Districts offer the potential to jump start the Government's industrial strategy, given the structures and strategies already in place within city regions, linking with the devolution agenda in England and regional policies in Scotland and Wales. Districts can be seen as a way to align local strengths to local interests and social innovation. The Government's productivity strategy outlines that "the government has made a clear commitment to make the UK the best place in Europe to innovate and create the ideas that help grow a business." It also states that "cities are at the heart of a dynamic economy, providing deep markets for

labour and enabling the rapid diffusion of ideas and vibrant competition between firms. The concentration of activity within cities itself contributes to productivity through the sharing of knowledge and ideas, the pooling of labour, the specialisation and matching of supply and demand and the sharing of infrastructure.”

The smart specialisation strategy also fits well with the approach adopted in the leading UK Innovation Districts which take forward many of its core principles. . For example, smart specialisation “[recognises] that that innovating firms need to work closely with universities, other centres of research, Government delivery partners and with wider groups representing civil society;” a key aspect of the Innovation District model. Sharing good practice about how and whether the objectives of smart specialisation can be applied within Innovation Districts will be extremely useful to the key partners and arguably also to government and business.

As the trend towards Innovation Districts gathers pace, there needs to be a shift from concentrating attention on sectors towards a focus on realising the potential of places. There are knowledge-spillovers and innovation returns from greater agglomeration across a range of sectors. The lack of available funding for place-based projects as opposed to sectoral ones hampers the ability to develop new and existing innovation ecosystems.

There has been growing interest in Innovation Districts in the US and internationally. A range of exemplars have evolved in recent years but the UK story is less well known, despite the success achieved by the first wave of Innovation Districts, and the huge potential of others. As a result, there is a risk that the UK will not grasp this opportunity fully. There is a need to ensure that Innovation Districts secure the investment and policy support necessary to maximise their success

What is the potential scope of the project?

A self-financed network has already begun to grow between KQ London, KQ Liverpool, the Oxford Road Corridor, the Queen Elizabeth Olympic Park, Innovation districts in Leeds and Glasgow Waterfront. There is the potential to grow and expand this network to include other areas Bradford Digital Health Enterprise Zone; Bristol Temple Quarter; Newcastle Science Central; Nottingham Innovation Park; and the Sheffield Innovation District. This group is unique in that:

- It is the only national group focused on having regional impact with benefits of shared learning and resources across the UK.
- This is a unique partnership globally which could provide the UK with a unique competitive advantage.

There are three strands to this project. The first is a financing for a formal network across UK Innovation Districts with a defined governance structure recognised by Government. The network will facilitate the sharing of best practice between organisations particularly between nascent and mature Innovation Districts. The culmination of this strand will be an annual conference which will engage local and national government representatives, developers, architects and education and cultural institutions.

The second strand will be the commissioning of in-depth research in collaboration with central Government on key areas, which will allow the formation of evidence-based policy for Innovation Districts. Topics identified include promoting inclusive growth, supporting and developing start-up ecosystems and models of network brokering.

The third strand will be funding for a series of programs which could be implemented and scaled by Innovation Districts; drawing on best practice. For example, the London Legacy Development Corporation has developed ‘Echo: the Economy of Hours’ for the Queen Elizabeth Olympic Park. Echo is a free to use, online platform for the buying and selling of skills, services and resources. The Knowledge Quarter has supported the delivery of a Primary Careers Conference, a model of aspiration-raising for students in year 5 from vulnerable groups. KQ Liverpool has experience in creating innovative workspaces with both corporate and university buy-in and the Oxford Road Corridor is an example of good practice in place-making that others will wish to share.

Economic case	
<i>What are the anticipated benefits and risks?</i>	The benefits include better policy development and evidence for Government, increased sharing of resources, knowledge transfer across different UK areas and increased joint activity across institutions, both within cities and cross-city. Specific projects and initiatives can also increase UK productivity, social mobility, increase access to good quality jobs and support foreign direct investment across the UK.
<i>What are the likely costs of the project?</i>	The project has a number of different costs depending on individual strands: - £75k will be needed for the first 2 – 3 years to get the network off the ground. Costs could be diminished over time as activities such as conferences begin to secure their own revenue and sponsorship. This will include the hiring of a dedicated network coordinator. - £50k a year for 2 – 3 years for the commissioning of research to build the evidence on specific areas on innovation districts within a UK context. - £250k per year to pilot innovative projects. The first project will be the development and expansion of 'Echo' into other clusters in the UK. - £12k to evaluate the impact of the effectiveness of the network and its activities after 2 years.
Commercial case	
<i>Can the project be delivered? Is it viable?</i>	There has been an increased level of interest from key sectors within place making and the local innovation agenda both locally and nationally, including but not limited to developers, trusts, cultural, Government departments and education and cultural sector organisations. Given the innovative nature of such a network, after a period of time, the network could look to commercialise some of its activities to supplement its income.
Financial case	
<i>Is the required funding available?</i>	The project will require initial seed funding.
Management case	
<i>How will the project be managed? Is there sufficient capacity?</i>	There is management capacity across the Innovation Districts network. All have successful experience in managing complex multi-stakeholder networks. The combined knowledge, skills and resources of the Innovation Districts network will ensure the project is technically sound.

Project 2: Building the brand of London's Knowledge Quarter

- A.4 The Science and Innovation Audit demonstrates strong links between the knowledge assets in the Knowledge Quarter and business growth. The concentration of assets within the Knowledge Quarter is both unique in the UK and well 'networked' nationally and internationally. In that context, **the Knowledge Quarter ought to be a powerful brand, which can be deployed to attract new investment into the UK**, much in the way that 'Tech City' has built on the credibility of the digital cluster around Shoreditch to help promote investment in digital tech nationwide.

A.5 However, the Knowledge Quarter remains largely absent from the London and UK investment narratives. This is a missed opportunity – and one which could be relatively easily resolved:

<i>Project outline</i>	
<i>Name of the project</i>	Building the Brand of London's Knowledge Quarter
<i>Summary of the project</i>	The Knowledge Quarter has an emerging brand. The SIA demonstrated an increasing awareness of the area within a mile of King's Cross as hosting a concentration of institutional and business innovation assets, particularly within the themes of the SIA. If promoted in a more coherent and effective way, alongside the development of a long-term 'strategic spatial vision' for the area, the Knowledge Quarter could increase its effectiveness as a core investment location for London and the UK. This project seeks to 'build the KQ's brand', both nationally and globally.
<i>Who are the key partners?</i>	KQ businesses, universities, local authorities and institutions Inward investment bodies (London & Partners and DIT) FCO/ BEIS (Science & Innovation Network) Commercial developers and investors
Strategic case	
<i>What problem are you trying to solve – what is the rationale for intervention?</i>	While many of the core assets of the Knowledge Quarter are long established, several – such as the Turing Institute, the Crick and (in its current location) the British Library – are new. The area has also experienced significant regeneration in recent years, which is continuing with the redevelopment of Euston. At the same time, the KQ is developing its role as a focal point for interaction between business and the knowledge base, particularly within the themes of the SIA. The KQ is therefore an important asset for London and the UK; it contains a concentration of science and research assets, and fosters relationships that could not take place elsewhere. However, beyond the KQ itself, the 'brand' is not widely recognised. The success of the area around Shoreditch in clearly identifying itself with the 'creative digital' (tech) sector suggests that there is potential in creating a clearer brand/ identity for the KQ. This will not be based on a single sector but will focus on the interplay between the area's key strengths, i.e. Health & Life Sciences, Digital Collections and AI / machine learning — a combination that arguably is unique to the KQ.
<i>What are the links to current policy and what are the existing gaps in provision?</i>	Currently, the concept of the Knowledge Quarter is recognised and used by a number of institutions and businesses in the KQ, and the Knowledge Quarter Partnership has been successful in growing the 'brand', extending the consortium and creating further recognition with central and local Government. However, it is not at present used by London & Partners (the Mayor of London's promotional agency) nor by the Department for International Trade in promoting the UK's offer, e.g. as part of the 'GREAT' campaign. We believe this to be a significant omission.

<i>What is the potential scope of the project?</i>	We envisage that the project will involve a long-term positioning of the Knowledge Quarter as a key component of London & Partners' and DIT's investment promotion activity, respectively, demonstrating and maximising value from the KQ's importance to the UK's innovation base. Alongside this, there is an opportunity to promote the KQ brand overseas through the thematic programmes of the Science & Innovation Network (SIN, run jointly by the Foreign & Commonwealth Office and BEIS). The 'training/ skills' side of the KQ could be marketed to potential undergraduate and postgraduate students through Study London, the Mayor's official university guide. The marketing could include promotion of the new 'Start-up' visa (replacement for the current Tier 1 Entrepreneur visa), which is due to launch in spring 2019. The campaign will highlight the opportunities for new firms to join a ready-made network in the KQ (i.e. the KQ Partnership) that can support and help grow their business.
Economic case	
<i>What are the anticipated benefits and risks?</i>	<u>Benefits</u> Increased investment in the Knowledge Quarter (including net additional investment into the UK) Increased recognition of the KQ as an internationally significant innovation district <u>Risks</u> Project not sustained/ lacks traction with Government and other stakeholders Focus on one area of London/ UK has the potential to be detrimental to other areas, by concentrating inward investment in one place
<i>What are the likely costs of the project?</i>	To be determined, but potentially significant over the long term.
Commercial case	
<i>Can the project be delivered? Is it viable?</i>	Yes in principle, but needs to be developed further. We propose to consult with DIT, FCO and BEIS on the best way forward.
Financial case	
<i>Is the required funding available?</i>	Not centrally held at present. Pump-priming by Government would be beneficial in the first instance.
Management case	
<i>How will the project be managed? Is there sufficient capacity?</i>	To be determined, and subject to discussion with DIT and other stakeholders beyond the current KQ consortium.

Project 3: Building stronger institutional ties

- A.6 The development of this Science and Innovation Audit involved joint work across all the KQ's universities, non-university research institutions and local authorities and many local businesses, and was facilitated by the (now well-established) Knowledge Quarter Partnership. Through the SIA process, **we identified several opportunities for institutional partners to increase collaboration, building stronger, deeper, ties and growing the scope for 'open innovation':**

Project outline	
Name of the project	Building stronger institutional ties
Summary of the project	The Knowledge Quarter contains an impressive stock of universities and non-university institutions. However, despite close proximity, links between research activity (and the efforts made by each institution to foster entrepreneurship and knowledge exchange) are often limited. This project aims to develop capacity for collaboration , developing deeper links across the KQ's institutions.
Who are the key partners?	Universities, non-university research institutions, corporate businesses, start-ups, business support providers
Strategic case	
What problem are you trying to solve – what is the rationale for intervention?	Despite the concentration of major institutions in the KQ, the linkages between them are more fragmented than they should be – and the relative 'isolation' of individual institutions limits the extent to which they can collectively be more than the 'sum of their parts' locally. Building on the SIA, a stronger shared knowledge of KQ's strengths, and increased opportunities for formal collaboration should help to nurture increased informal ties and will help to promote opportunities for open innovation. There is strong demand to create these ties – and individual organisations have tried to create networking events for particular sectors (Benevolent AI coordinated an 'AI in Bioscience special interest group' and UCL runs 'Research Programming Technical Socials'). However, without dedicated resource, these events tend to be ad hoc and often only possible because of the support from key individuals (and later disbanded when these individuals change roles). Creating networks and facilitating opportunities for knowledge exchange is time intensive and requires resourcing of its own right. When similar activity has been done in other countries as part of cluster-forming mechanisms, the result has been increased productivity; particularly in relation to SMEs. In some cases, policy interventions were found to have facilitated the initiation of collaborations and relationships that would not have occurred otherwise. Given the concentration of assets as highlighted by the KQ SIA, there is a potential productivity loss by not facilitating these networks. The Knowledge Quarter London Ltd has created a model which has succeeded in creating 'weak ties' between institutions. Through a common brand and shared purpose, the Knowledge Quarter is able to create the conditions by which networks can be formed. However, the Knowledge Quarter does not have the resources necessary to create 'strong ties;' particularly within key thematic areas. The creation of strong ties requires specialised facilitators which goes beyond traditional network or project management. Facilitators need to have a deep understanding of the latest research for particular thematic topics, have to communicate effectively and develop enthusiasm to sustain involvement among enterprises and knowledge actors.
What are the links to current policy and what are the existing gaps in provision?	As identified within the KQ SIA, there is an exceptional asset base on which to build strong ties. Research institutions in the KQ will have their own knowledge exchange teams and many large organisations will do similar activities internally or on a less frequent basis for a wider network. Through coordination, it is possible to leverage these assets and events into a defined program of activity. The Knowledge Quarter London Ltd provides a governance structure and existing network with which to start building these strong ties.
What is the potential scope of the project?	The project is likely to initially involve a small joint coordination function across the KQ institutions, with a remit to support joint and complementary activities in relation to the SIA themes. Over time, this could expand into (for example) shared business development and/ or financial support mechanisms.

The project will start with coordination of 6 – 10 narrowly defined special interest groups across the three thematic areas of the SIA.	
Economic case	
<i>What are the anticipated benefits and risks?</i>	There are benefits which include: an increase in networks, an increased sharing of resources between institutions, increased joint activity, an increase in the creation of new businesses, and increased in business productivity.
<i>What are the likely costs of the project?</i>	Direct costs likely to be those associated with a small team – perhaps £150-250k per year. Three facilitators will be hired within the three thematic areas of the Knowledge Quarter.
Commercial case	
<i>Can the project be delivered? Is it viable?</i>	In principle, yes
Financial case	
<i>Is the required funding available?</i>	Not at present within a central resource, although potentially contributions could come forward from partner institutions. In kind support will be provided in terms of venue and workshop space, access to expertise and mentorship and administrative resource.
Management case	
<i>How will the project be managed? Is there sufficient capacity?</i>	To be determined – likely to require some coordinated joint management across the KQ institutions.

Project 4: Developing the start-up ecosystem

- A.7 Through the Audit, we identified many strengths in the KQ's innovation ecosystem, from the universities' incubator facilities and investment funds to the range of work spaces and support programmes delivered through the private sector. But, **relative to the area's innovation assets, the supply of accelerators is limited and there is an acute shortage of flexible and affordable workspace** in proximity to the knowledge base.
- A.8 This presents a challenge to KQ's resilience: to **sustain our unique combination of assets and potential, we need to ensure that it can constantly renew itself**, bringing forward new, disruptive technologies and businesses and maintaining our competitive edge:

Project outline	
<i>Name of the project</i>	Developing the KQ start-up ecosystem
<i>Summary of the project</i>	Linking with several other initiatives, this project will build external awareness of the developing ecosystem within the KQ, helping start-up businesses to make links to investors; find appropriate property and move-on space; link into the key networks linked to deep tech; and expand existing start-up incubator programmes. It will build on the on-going activities of all the HEIs but will also add to them. Developing and supporting the area's start up ecosystem will ensure the area is able to maintain and improve its current level of innovative activity.

<i>Who are the key partners?</i>	UCL and City, University of London; British Library BIPC, Universities, research organisations, corporate businesses, start-ups, business support providers
Strategic case	
<i>What problem are you trying to solve – what is the rationale for intervention?</i>	Within KQ, there already exist most of the component parts of a vibrant innovation ecosystem. However, through interviews with stakeholders, workshops and desk research – a number of issues relating to the area's growing start-up and entrepreneurship scene were identified. These include: • A lack of awareness, coordination and established networks from key actors within the area's start-up ecosystem. • A lack of knowledge from investors and start-ups about the area's assets which might impede attraction of capital and talent (although there is evidence that this is quickly changing). • A relative lack of accelerators, incubators and managed workspaces relative to other parts of London; particularly in relation to the area's science and innovation assets. • A lack of available affordable workspace for early-stage start-ups relative to demand. • A lack of established networks between different actors (including HEIs and corporates) within the area's start-up ecosystem. Within the literature on clusters and innovation districts, start-ups are an integral part of a cluster's ability to commercialise research and attract investment. American innovation districts have recognised this and introduced a number of policy interventions. For example, Boston has introduced an 'innovation component' for new office and retail developments where 15% of space is earmarked for start-ups. Other areas have built a range of 'cultivators' to support start-ups and entrepreneurs.
<i>What are the links to current policy and what are the existing gaps in provision?</i>	The KQ area has a number of important actors within the start-up space. This includes a number of higher education institutions including City and UCL (both providing incubation space), business support providers like the British Library's Business & IP Centre, co-working spaces including Impact Hub and Rocket Space, and venture capitalists including LocalGlobe. This provides a starting point for the creation of a new model for supporting and growing an area's start-up ecosystem. A model that can potentially be replicated across different parts of the UK; building on the experience of the Knowledge Quarter in creating successful multi-stakeholder partnerships and collaborations. This will also build on lessons and experience from the creation of Tech City. The project will work with existing assets and actors in the area to create a new governance structure which will: • Establish a start-up network and coordinate resources and actors within the area. • Signal the area to investors, corporates and other start-ups as a world-class hub for innovation. • Provide the leadership needed to attract corporate investment and develop joint projects.
<i>What is the potential scope of the project?</i>	The project will require a coordinator and initial seed funding. Key elements of the project will be: • Creating the framework for a start-up network and establishing a governance structure. • Creating a program of activity; including public events and networking events between members of the start-up network. • Scoping initiatives which could develop additional physical infrastructure for start-ups and coordinate investment by local boroughs and corporates. The start-up network will also open up the potential to implement projects which will leverage and scale the KQ's entrepreneurship ecosystem –

particularly the area's dynamic and young population. These projects will be made possible by the network's established governance system. These include:

- Developing entrepreneurship in doctoral students. In 2016/17 within the Knowledge Quarter there were over 8,000 postgraduate research students. Often these students are on the cutting edge of scientific research and have developed specialist skills; particularly within the thematic areas identified by the SIA. Leveraging links developed through the start-up network and the concentrated pool of postgraduate research students, the Knowledge Quarter will create a programme which will create a new talent pipeline for start-ups and incentivise the creation of new businesses by research students.
- Creating a pan-KQ accelerator with clear links to the Tier 1 Graduate Entrepreneurship visa. There is general underuse in the number Tier 1 (Graduate Entrepreneur) visas that higher education institutions can sponsor. This is despite the fact that recent UKVI rule changes have simplified its criteria. There are over 50,000 international students across higher education students within the Knowledge Quarter. More than 10% of the UK's total international student population is based within its one mile radius (representing almost half of the entire international student population within London). The KQ's HEIs could participate in a pilot part-time accelerator programme geared towards (but not exclusively for) supporting applications to the Tier 1 Graduate Entrepreneur visa. Central to this proposal is the creation and ability for a lead HEI to house a 'Business Immigration Advice Hub' which will support all students from KQ HEIs with immigration advice alongside a traditional accelerator programme. This 'hub' will take monitoring responsibility and any administration costs related to the Tier 1 (Graduate Entrepreneur) process.
- Developing a technology and early stage start-up incubation programme, building on the existing London City Incubator (LCI) scheme (an innovation catalyst programme designed to improve the success of commercialisation at City, University of London and to assist local high growth companies in accessing funding). This could involve expanding the programme to other universities within the KQ, developing stronger links with funding and investment bodies (such as UKRI, angel investors and venture capitalists), and helping to bring the local 'deep-tech' start up community closer to university assets and expertise. Ultimately, this could lead to a partnership similar to the successful (and long-established) SETsquared incubator elsewhere in the UK⁹².

The key advantage of creating and implementing projects within the KQ is the proximity of institutions which enables the sharing of resources and the building upon of existing projects and expertise.

Both projects will be able to match students from a range of different institutions and connect them with the area's start-up cluster; creating a flow between academia, industry and the area's start-up community which could become internationally significant.

Economic case

What are the anticipated benefits and risks?

The benefits will include increased coordination and shared resources, increased survival rates of start-ups, better coordination between corporates and start-ups and an increased number of start-ups in the Knowledge Quarter.

⁹² SETsquared is a collaboration between the universities of Bath, Bristol, Exeter, Southampton and Surrey to support high tech start-up companies, student enterprise and the commercial impact of research. It has been cited as "the world's top business incubator managed by a university" (UBI Global, February 2018). See www.setsquared.co.uk

<i>What are the likely costs of the project?</i>	We propose that the initial seed funding of one year for the project be £75,000 a year with in-kind contribution such as accommodation, legal advice and administrative support provided by partners. If the project is viewed as a success, then funding for additional years will be matched by KQ partners or secured through sponsorship. In terms of scoping project costs, the running of a central immigration advice hub tailored towards Tier (Graduate Entrepreneur) will cost £75,000 a year. The running of an accelerator program will require £100,000 a year. A doctoral entrepreneurship pipeline will require £175,000 a year. Expanding the technology and start-up incubator programme could potentially require around £750k in the first year of operation (in addition to investment funding for a Market Development Fund).
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Commercial case

<i>Can the project be delivered? Is it viable?</i>	In principle yes.
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Financial case

<i>Is the required funding available?</i>	Funding commitments have not yet been agreed, although the amounts required (at least in the early stages) are modest. Seed funding can leverage the potential for corporate partnerships and sponsorship. KQ Universities and institutions (like the British Library and other research organisations) can be leveraged to provide in-kind support through the supply of venue space, expertise, access to specialist equipment, mentorship and other forms of corporate support.
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Management case

<i>How will the project be managed? Is there sufficient capacity?</i>	Management arrangements are to be determined, although Knowledge Quarter London Ltd could play a key coordinating role. There are a number of partners who have the ability and expertise to deliver projects.
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Project 5: Unlocking the NHS Estate

- A.9 While the life sciences sector across London – and especially within the KQ – is expanding rapidly, this Audit has demonstrated that physical infrastructure to support its expansion is very limited, especially for wet lab space. However, the KQ has a significant stock of NHS assets: this could contribute to a solution, at the same time as enhancing the (already strong) connections between the NHS and the life science research and development base:

Project outline

<i>Name of the project</i>	Unlocking the NHS Estate (to support delivery of wet lab space in areas of very high demand)
<i>Summary of the project</i>	This project will “make the case” to HM Treasury to intervene to unlock the surplus NHS Estate in and around KQ, recognising the need to cut through layers of structure, ownerships and decision-making.
<i>Who are the key partners?</i>	London Estates Board including signatories of 2017 London Health and Social Care Devolution Memorandum of Understanding (https://www.london.gov.uk/sites/default/files/what_health_devolution_means_for_london_2017.pdf) . Locally this includes Camden Council, North Central London CCG, the GLA, MedCity, NHS, DoH

Strategic case	
<i>What problem are you trying to solve – what is the rationale for intervention?</i>	The life sciences sector across London continues to expand apace with increased levels of investment in both start-ups and scale-up firms. Within this context, KQ is a particular focus given the strength of its science assets and its location. The life sciences sector needs the right physical infrastructure in the right locations including wet labs if the commercial potential of its world class science is to be realised. KQ has a scientific endowment that is outstanding but the only facility within KQ currently – London Biosciences Innovation Centre (LBIC) – is full and has a waiting list. While some expansion is anticipated in the KQ area, it is imperative that work on cluster development captures the dynamic growth associated with The Francis Crick, Alan Turing Institute, Google, Wellcome Trust and UCH – now and into the future. Part of the solution rests in maximising the potential use of surplus NHS estate in key locations – but this process has proved to be difficult due to the complexity of interests involved, even though there are known to be surplus NHS buildings within KQ.
<i>What are the links to current policy and what are the existing gaps in provision?</i>	Life sciences are a national priority and the life sciences sector deal was one of the first to be published, in August 2017. The gaps in provision in and around KQ are well known and reasonably well document – see for example the study commissioned by MedCity from Creative Places (and referenced in the main report)
<i>What is the potential scope of the project?</i>	Building on the progress made through London Estates Board and the devolution deal, the project is concerned with modelling building costs and returns in order to persuade HM Treasury of the merits of a more creative approach to the use of the NHS Estate. The KQ area will be used as a pilot with the intention that a sound methodology might be developed and then rolled out. The challenges are well understood, but a number of parties have struggled to make the case in a manner that has had traction at the centre of government.
Economic case	
<i>What are the anticipated benefits and risks?</i>	This project is concerned mainly with making the case to HM Treasury and then working with different parts of the NHS to effect change across the surplus NHS estate. The project itself does not have huge risks – but there will be a missed opportunity if it is not taken forward.
<i>What are the likely costs of the project?</i>	This is initially a small piece of modelling work. It needs to be done thoroughly and well and the costs will be in the order of £100k
Commercial case	
<i>Can the project be delivered? Is it viable?</i>	N/A (as the proposed project is a research study)
Financial case	
<i>Is the required funding available?</i>	No – some revenue funding will be required to resource the research that needs to be done.
Management case	
<i>How will the project be managed? Is there sufficient capacity?</i>	Camden Council will commission and then steer the proposed project with assistance at the Steering Committee level from MedCity and others as potentially required.

Project 6: Digital content innovation hub

- A.10 This Audit demonstrates that there is potential in commercialising the value of the digitalised cultural and heritage collections in the Knowledge Quarter. However, this potential is difficult to realise, partly because of a lack of awareness by entrepreneurs of the scale of the resources available, and partly because the commercialisation of these resources falls outside the 'core business' of the institutions that hold them.
- A.11 This challenge is not unique to the Knowledge Quarter. But **the KQ presents a unique opportunity to address it, given the co-location of genuinely world-class heritage assets, the strength of the KQ's data science base and the strength of the local tech business and investment community.** There is potential in bringing the three together, and partners – led by the British Library – are exploring the potential of an 'innovation hub' to unite the holders of data with those who generate new services and products from it:

Project outline	
Name of the project	Developing a Digital Content Innovation Hub
Summary of the project	This project will provide a physical and virtual digital content innovation hub that will stimulate innovation by actively bringing together technology companies, digital content holders within the British Library and other institutions, designers and artists. The aim of the 'hub' will be to: increase awareness of the collections' data holdings and facilitate access to them; showcase examples of innovation, and provide space, support and access to investment to innovators seeking to use the collections creatively.
Who are the key partners?	The British Library, The British Museum, Design Council, UCL, Digital Catapult
Strategic case	
What problem are you trying to solve – what is the rationale for intervention?	Within the Knowledge Quarter, the cultural collections are starting to show their potential as a source of revenue for the organisations holding them, as well as commercial opportunities for broader business community (both SMEs and large businesses). However, this potential has yet to be realised, due to a lack of understanding and commercial access to the scale of resources that the collections offer and the relatively limited number of examples – so far - of effective commercialisation. In essence, while there is a very significant asset base and there is a <i>potential</i> market, the market has yet to come to fruition: the potential applications which will drive demand and supply are not yet known. This project is therefore about stimulating a new market: one in which the KQ partners have a strategic interest (and assets to bring to the table), but which can only be realised through private sector innovation. If we can stimulate the market in the Knowledge Quarter, there is likely to be scope for further development elsewhere in the UK, given the digital collections in other centres. However, the rich concentration of collections, technological expertise and entrepreneurial capacity in the KQ makes it the ideal place to start.
What are the links to current policy and what are the existing gaps in provision?	Using technology to achieve greater economic use of public sector data is recognised as a priority in the Digital Strategy, the work of the Digital Catapult and Future Cities Catapult, the NHS digital strategy and the range of Smart Cities initiatives across the UK. Developing access to heritage and cultural collections data is consistent with this policy direction. Regarding gaps in existing provision, there is no existing facility to support the commercial exploitation of digital collections, although the British Library

	maintains a significant business interaction and engagement presence through the BIPC.
<i>What is the potential scope of the project?</i>	It is envisaged that this project will be physically based in the Knowledge Quarter to benefit from the proximity to key digital collections and relevant expertise. However, it will also have a 'virtual' element, and will seek to promote support commercialisation through links with large businesses and SMEs regardless of location.
Economic case	
<i>What are the anticipated benefits and risks?</i>	Benefits include: • New product creation resulting from the exploitation of scientific, cultural and heritage collections • New opportunities for revenue resulting from the commercialisation of assets • New business creation • Roll-out of commercialisation opportunities to other institutions holding collections elsewhere in the UK • Opportunity to demonstrate innovation and build a market, with potential wider application • More coordinated approach to the commercial use of digital content, developing an environment that can bring together a mix of relevant expertise (e.g. copyright, preservation, new technologies) Risks include: • Ultimate lack of demand (the project is responding to an 'unproven' market), so will need to demonstrate flexibility • Insufficient level of investment to signal potential to business and investors • Focus on only certain technologies (e.g. AR and VR), which while important in this context, are only one route that can be taken by business.
<i>What are the likely costs of the project?</i>	Potentially £5m over 3 years to support the development of a physical and virtual centre.
Commercial case	
<i>Can the project be delivered? Is it viable?</i>	Yes. This project can be delivered as it will build on the significant current expertise of the BIPC at the British Library, Digital Catapult's existing programmes, and the KQ organisations' existing digital partnerships. As the hub will deliver digital benefits to the organisations which are strategically committed to developing their capacity in digital environment, the project outcomes will be in time incorporated into their business as usual, thus making this project viable and sustainable.
Financial case	
<i>Is the required funding available?</i>	Funding is not available within the existing resources, and will have to be sought as an investment.
Management case	
<i>How will the project be managed? Is there sufficient capacity?</i>	The project will be managed as a Strategic Partnership between the key partners who will establish relevant agreements and a Management Structure. Key staff will have to be recruited or seconded from the key partner organisations. The capacity to develop this project will be available within the partnership. Delivery capacity will be dependent on the new investment.

Project 7: Developing KQ Visas

- A.12 One of the KQ's core strengths is its ability to attract talent from across the world. This represents a net gain for the UK, as academic expertise, investment capital and entrepreneurial spirit are drawn to the KQ's institutions and businesses. The 'international' nature of the KQ is part of its essential character, and will be key to its future success. We want to ensure that we maximise the KQ's international attractiveness and ensure that it is a convenient and welcoming place to research, innovate and create:

Project outline	
<i>Name of the project</i>	Developing 'Knowledge Quarter Visas'
<i>Summary of the project</i>	Through the SIA, we have established that access to international talent is a key characteristic of the Knowledge Quarter – and will be fundamental to its future success. This project aims to encourage talent to come to the KQ by promoting access to visas specifically linked with exceptional talent.
<i>Who are the key partners?</i>	KQ academic and institutional partners, business, Tech Nation and Designated Competent Bodies
Strategic case	
<i>What problem are you trying to solve – what is the rationale for intervention?</i>	The Knowledge Quarter relies on a continual flow of international talent. This reinforced by the universities' strong international connections, the presence of international corporations (such as Google), international transport connections via St Pancras and the attractiveness of the KQ to people from overseas looking to invest and start a business. Historically, London has been successful in attracting international talent. This will continue to be vital after Brexit, and it is important that there are mechanisms in place to make the process of coming to the KQ to drive science and innovation as smooth as possible. Some KQ stakeholders report concerns about their ability to maintain the area's leading international position if and when the UK leaves the EU. However, take-up of some existing visa categories is lower than it should be, the system is complex to navigate and good practice is not always widely shared.
<i>What are the links to current policy and what are the existing gaps in provision?</i>	Current visa policy is nationally managed, with different visa categories offered within the UK's points-based system. Locally, our approach to securing international talent must work within this system, which will only be varied at national level. However, more could be done to drive up take-up and understanding.
<i>What is the potential scope of the project?</i>	The scope of the project is in development. However, potentially, it could involve three elements: • <i>Driving demand:</i> encouraging stronger take-up, particularly in Tier 1 (Exceptional Talent), for which there should be high potential demand, given the concentration of talent in the KQ. This might involve working with organisations like Tech Nation to help promote the scheme. • <i>Encouraging university participation in Tier 1 (Graduate Entrepreneurship) visas.</i> Anecdotally, not all London universities are strongly engaged the scheme (although it will be useful to have some more data), but there is expertise and good practice that could be shared • <i>Investigating the potential to Create a Knowledge Quarter Designated Competent Body.</i> This will need to have a national reach to be viable, and we will need to think through what it will add to the existing DCBs (given that the themes overlap with KQ's focus), but there might be a value in SIA consortia coming together to proactively attract exceptional talent

Economic case

What are the anticipated benefits and risks?

Benefits

- Higher levels of take up of Tier 1/ Tier 2 visas
- Businesses and institutions able to access talent
- Additional business investment and job creation

Risks

- Risks to sponsoring institutions if visa rules not followed correctly
- Inability to achieve stronger take up due to inherent design of the system

What are the likely costs of the project?

Minimal. To be delivered by partners with some additional management support

Commercial case

Can the project be delivered? Is it viable?

Yes, although further work needs to be done to scope the project

Financial case

Is the required funding available?

Unlikely to be a significant funding requirement

Management case

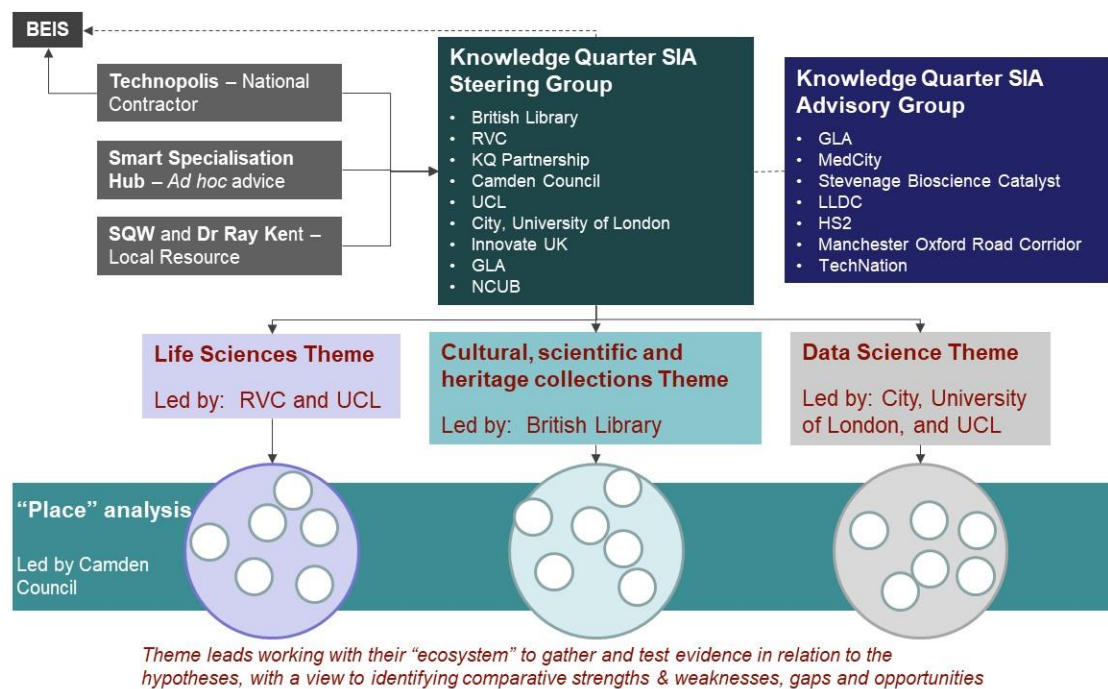
How will the project be managed? Is there sufficient capacity?

To be determined

Annex B: How the KQ SIA was developed

- B.1 Following an Expression of Interest which was submitted to central government in summer 2017, the Knowledge Quarter's Science and Innovation Audit was substantively developed over eight months from November 2017.
- B.2 The consortium that completed the KQ SIA was a new cross-sectoral grouping which was formed for the purpose. The overall management and governance structure that it devised to oversee the SIA process is set out in the diagram below.

Figure B-1: Knowledge Quarter Science and Innovation Audit: Governance arrangements



- B.3 The preparation of the KQ SIA was overseen by a **Steering Group** and supported by a team from **SQW**.
- B.4 The **Steering Group** was chaired by Karen Galey (Camden Council), and included: Maja Maricevic (British Library); Patrick Jones and Chloe Williams (Camden Council); Ray Kent (Royal Veterinary College); Ian Gibbs (City, University of London); Jim Collins, Ben Gascoyne and Brian Carter (UCL); Eva Sharpe (Greater London Authority); Daniel Stevens (Knowledge Quarter); Andrew Basu-McGowan (NCUB); and Colm Watling (Innovate UK). This Group met (approximately) monthly to review progress. In addition, all members of the Steering Group made substantive contributions to the process of the SIA.
- B.5 The Steering Group was supported by a wider **Advisory Group** which comprised key stakeholders with an interest in the Audit, but generally from a wider spatial perspective. Some members of the Advisory Group were focused on other parts of London (e.g. LLDC) and some on areas outside London (e.g. Stevenage Bioscience Catalyst; Manchester Oxford Road Corridor) but all saw the relevance of the process and contributed to it.

B.6 Reflecting the structure of the KQ SIA there were, in addition, key responsibilities in relation to specific parts of the SIA:

- **Daniel Stevens (KQ)** led on **cross-Thematic elements**. He took responsibility for convening *two wider stakeholder workshops* (which considered the KQ in its entirety), one near the start of the process and a second towards the end. In both cases, these were attended by over 40 stakeholders from across KQ. He also managed the wider *Reference Group* (which met once) and used networks to raise awareness of both the *Call for Evidence* and the *stakeholder e-survey*, both of which were launched at the start of the process.
- **Ray Kent (RVC)** was **Theme Lead for Life sciences**, supported by **Jim Collins (UCL)**. Ray convened one *Theme-specific workshop* which was held at The Francis Crick Institute and attracted around 30 delegates from all parts of the life sciences sector. He also led on some *case studies* of relevance to the life sciences theme and arranged for an *e-survey of tenants of London Bioscience Innovation Centre*. In addition, alongside Daniel, Ray played an important over-arching role in relation to the Audit as a whole.
- **Maja Maricevic (British Library)** was **Theme Lead for Cultural Collections**. She was supported by a sub-group consisting of Jo Townsend/ Ben Gascoyne (UCL); Carl Heron (British Museum); Tom Campbell (Knowledge Transfer Network) and Jane Winter (School of Advanced Study, University of London). The Cultural Collections Theme held one *workshop* with organisations and institutions with an interest in the field.
- **Ian Gibbs (City, University of London)** was **Theme Lead for Data Science**, supported by Jim Collins (UCL), Birgita Jurisic (City, University of London) and Ben Gascoyne (UCL). There was *one theme-specific workshop* focused on data science which again was well attended, as well as two *theme group* meetings. The data science group also supported prepared *case studies* relevant to the data science theme.
- **Patrick Jones and Chloe Williams (London Borough of Camden)** led on the **cross-cutting Place strand**. Within this remit, they focused on *substantive data and evidence gathering*, particularly in respect of the availability of workspace across KQ. They also completed some *major case studies* linked to the spatial elements of the Audit and plans for the future.

Evidence gathering

B.7 The SIA relied on a wide range of evidence-gathering, some led by Theme/Place leads and some by SQW. These elements were sometimes cross-cutting and sometimes Theme-specific.

B.8 The preparation of the SIA involved:

- An **esurvey of local organisations** to ascertain their existing relationships and partnerships, their innovation activities and the value of the Knowledge Quarter as a location for them

- An open **call for evidence**: universities, businesses and other partners were invited to submit evidence of their innovation assets and activities
- One **stakeholder workshop** for each of the three Themes, and two high-level cross-cutting workshops across the KQ. These were hosted by key institutions in the KQ: the British Library (the Cultural Collections workshop); The Francis Crick Institute (life sciences) and BASEkx (data science).
- One **project development workshop** which considered the development of appropriate interventions to accelerate the development of the innovation ecosystem
- About 15 **business consultations** which were in-depth and explored processes of commercialisation and growth within KQ; several of these have been written up as case studies within this report
- A focused **esurvey of tenants of London Bioscience Innovation Centre (LBIC)**
- A review of **relevant literature**, ranging from London-specific documents (e.g. the Mayor of London's strategies); market and technology reports of relevance to one or more of the Themes; and policy-based analyses (including many of the documents linked to the Industrial Strategy)
- An **analysis of data provided by KQ partners** – with regard, for example, to the incidence of spin-outs
- Analysis of **core data provided by Technopolis**, the national contractors to BEIS. Technopolis prepared a core data report in January 2018, which included economic and demographic information, REF output data, details of research active organisations (derived from Gateway to Research) and participation in FP7 and Horizon 2020
- A review of the **bespoke analysis commissioned from Technopolis**. This work included gathering evidence from international comparators and a semantic analysis of research participations.

B.9 All these various elements have informed the Audit and underpin the analysis of gaps and opportunities in its conclusions. In turn, this led the SIA Steering Group to develop the strategy outlined in the final chapter of the Audit.

B.10 The timeframe for the work in 2018 is set out below. Feedback was received from both Technopolis and BEIS on the first draft (submitted in April), which informed the final draft (submitted at the end of June).

	Jan	Feb	Mar	Apr	May	June	July
Evidence gathering – by Theme, place and KQ-wide	✓	✓					
Theme-level reporting			✓				
Draft to Technopolis (national contractor)			✓	✓			
Development of actions and business cases				✓	✓		
Draft to BEIS						✓	
Finalisation							✓
High-level cross cutting workshops		✓	✓				

Annex C: Contributors to the KQ SIA

C.1 Many organisations from the KQ area (and beyond) contributed to this SIA, either through answering the survey, attending the workshops or responding to the call for evidence. A small number asked not to be named; the remainder are listed below. We are grateful to all of them for their time and help.

- Alan Turing Institute
- Art Fund
- Association of Medical Research Charities
- BenevolentAI
- Bio Nano Consulting
- Birkbeck, University of London
- British Land
- British Library
- BMJ (British Medical Journal)
- British Museum
- Camden Council
- Capital City College Group
- Capital Enterprise
- CILIP (Chartered Institute of Library & Information Professionals)
- City, University of London
- Cockpit Arts
- Crafts Council
- deltaDOT
- Design Council
- Digital Catapult
- Dreamstake Ventures
- Faculty of Public Health
- Forte Medical
- Foundling Museum
- Francis Crick Institute
- Google
- GuildHE
- HelpAge international
- Jupiter Diagnostics
- Impact Hub King's Cross
- IOM3 (Institute of Materials, Minerals and Mining)
- Institute of Physics
- Islington Council
- Knowledge Quarter
- KTN (Knowledge Transfer Network)
- Little Angel Theatre
- LocalGlobe
- LBIC (London Bioscience Innovation Centre)
- London Canal Museum
- London Higher
- London Metropolitan Archives
- London School of Business and Management
- London School of Hygiene and Tropical Medicine
- MedCity
- McCaldin Arts

- MOLA (Museum of London Archaeology)
- NBBJ
- New London Architecture
- Penningtons Manches
- Poet in the City
- Produce UK
- Reading Agency
- RebelBio
- Regent High School
- Royal College of General Practitioners
- Royal College of Physicians
- Royal Veterinary College
- Science Developments Ltd
- School of Advanced Study, University of London
- Scriberia
- Shadow Robot Company
- SOAS, University of London
- Springer Nature
- Theatre of Debate
- The Place
- UCL (University College London)
- UCLB
- UCL Press
- University of the Arts London (Central Saint Martins)
- Warwick in London, University of Warwick
- Wellcome Trust
- Westminster Kingsway College
- Wiener Library
- WMC - The Camden College
- Yale University Press (London)
- Zinc