CHAPTER 4.0

CONCLUSION

4.0 Conclusion

4. 1
In summary, UKCMRI will:

- Create a world class research institute of excellence to undertake scientific research with real world application and innovation
- Do so in an innovative way which helps to address the weaknesses identified in current UK medical research
- Contribute to the reduction of illhealth and disease and its economic burden
- Accommodate around 1,500 jobs, of which between 400 and 700 will be new jobs. These will be across a wide range of roles from research scientists to engineering, administrative and other support staff
- Create an average of around 600 construction jobs over a 48 month period, rising to over 1,000 at peak times
  Contribute to the development of scientific researchers at all levels including undergraduates and PhD students and providing summer placements and knowledge transfer
- Leverage additional research and increase GDP by around £16m every year once operational, through spillover effects
  Support potential for further investment in spinoff companies
- Provide increased local spending, estimated at up to £8m per annum
- Offer a variety of public outreach programmes aimed at engaging the local communities via workshops, conferences and youth events

APPENDIX A

QUANTIFICATION OF THE ECONOMIC BENEFITS OF SPILLOVER

Appendix A
Quantification of the Economic Benefits of Spillover

A. 1
The Economic Benefits of Spillover
The scientific and technological advances and knowledge flows generated by R&D activity can have multiple beneficiaries. R&D investment in one organisation may therefore be beneficial not only to that particular organisation ('internal spillovers') but could also 'spillover' to other organisations both within the same sector ('intra-industry spillovers') and in other sectors of the economy ('inter-sector spillovers'). The economic benefits of R&D investment are therefore not limited to any one body or, indeed, any one economic sector.

A. 2
Internal spillovers are benefits that are internalised by the body that is investing in R&D and could include its ability to employ knowledge and practical experience in future research, as well as financial gains from royalties and/or sales of a new product or process.[1]

A. 3
Intra-industry spillovers refer to R&D benefits that are captured by other firms in the same sector, such as increased productivity levels in response to external competition.[2]

A. 4
Inter-sector spillovers comprise R&D benefits undertaken in one industry but which are used in other sectors of the economy. A company could, for example, use a new technology to develop a new product or service.[3]

A. 5
The sum of all of these benefits represents the total 'social' return to the original investment in R&D.[4] In short, evidence shows that investment in life sciences generates additional national income for the UK.[5]

A. 6
Quantifying Spillover
In this section we look at investment returns for R&D in the life sciences, incorporating internal, intra- and inter-sector spillovers.

A. 7
The section is split into:
1. Additional private R&D induced by increased public medical research;
2. Economic Rent;
3. Combining (1) and (2) to calculate the total social rate of return.

A. 8
It should be noted that, while intra- and inter-industry spillovers can be international, this report concentrates on studies that focus on the national scale.

[1] Garau, M. and Sussex, J. Office of Health Economics 'Estimating Pharmaceutical Companies' Value to the National Economy' London: Office of Health Economics
[2] Henderson and Cockburn 1996 cited in Garau and Sussex
[3] Garau and Sussex 2007
[4] Health Economics Research Group, Office of Health Economics, RAND Europe (2008) Medical Research: What's it worth? Estimating the economic benefits from medical research in the UK London: UK Evaluation Forum ('HERG 2008')
[5] HERG 2008
[6] Toole, A. (2007) 'Does Public Scientific Research Complement Private Investment in Research and Development in the Pharmaceutical Industry?' Journal of Law and Economics 50:1 pp81-103
[7] Toole (2007)

Appendix A
Quantification of the Economic Benefits of Spillover

A. 9
(1) Additional Private R&D
Using US-based data about pharmaceutical industry investment within classes of medical technology between 1981 and 1997, Toole (2007) found that a dollar increase in public basic medical research stimulates an additional US$8.38 in pharmaceutical investment after 8 years.[6] A US$1 increase in public clinical research was found to stimulate an additional US$2.35 of industry R&D investment after three years.[7]

A. 10
Toole (2007) cautions against using these findings as definitive but nevertheless argues that both public basic and public clinical research stimulate additional private pharmaceutical R&D.

A. 11
(2) Economic Rent
Garau & Sussex (2007) estimate the value of two British-based pharmaceutical companies, AstraZeneca (AZ) and GlaxoSmithKline (GSK), to the UK's economy.[8] Both these companies are members of the British Pharma Group (BPG).

A. 12
Garau and Sussex (2007) estimate the net additional income and wealth brought to the UK by these companies' manufacturing and R&D activities in excess of the income they would be expected to generate in the next best alternative use(s) to which labour and capital would be diverted if AZ and GSK ceased to operate in the UK. This is called 'economic rent'.[9] It effectively measures how much poorer the UK would be if a particular industry was to stop operating within the country, even if all labour and capital released subsequently found re-employment elsewhere in the economy.

A. 13
Several factors impact the overall economic rent generated for the UK economy by AZ and GSK. These are:
- Producer rents, which include:
    - Economic rents earned from UK exports and UK tax revenues from these. This occurs whenever a good or service is sold above the cost of its production;
    - Economic rents earned from the overseas activities of UK-owned business and captured by British shareholders or the British Exchequer;
    - Labour rents earned by employees in the UK. This is significant in the pharmaceutical industry where wages exceed the average by around 10% for equivalent types of labour;[10]

[8] GGarau, M. and Sussex, J. (2007) Estimating Pharmaceutical Companies' Value to the National Economy: Case Study of the British Pharma Group London: Office of Health Economics; HERG et al 2008
[9] Economic rent refers to any excess earnings above the marginal opportunity cost of a production factor in a market economy. This applies to labour in that if someone earns £20,000 for a job and the next best job they could do pays £15,000, then the economic rent they are earning in their current job is £5,000. This principle similarly applies to capital where any one activity may yield greater profits adjusted for risk) than in the next best alternative use. [Garau and Sussex (2007) drawing on Milgrom and Robert (1992)]
[10] Hale and Towse (1995) cited in Garau and Sussex (2007)

Appendix A
Quantification of the Economic Benefits of Spillover

- Spillover effects from R&D activity captured by bodies other than the company making the original investment. Garau and Sussex (2007) estimate that the total social rate of return from BGP's private pharmaceutical R&D investment is 51%. Of this they estimate that 14% is captured by the investing firm, 26% by other firms within the same sector and 11% by other non-pharmaceutical sectors of the UK. BPG expenditure on R&D in 2005 was £2,170m, of which 11% is £239mill. Allowing for a +/- leeway of 50%, Garau and Sussex therefore estimate that the spillover effects of BPG companies' R&D expenditure might be between £120-£360m;
- Terms of trade effects, meaning the loss of a company's activities that positively contribute to a country's balance of trade. Without BPG companies' UK-based activities, the total trade gap that would need to be closed would be around £2.9 billion.

A. 14
Taking these factors into account, Garau and Sussex conclude that the net value of BPG companies to the UK economy is estimated to be at least £1bn annually and could be significantly higher.[11]

A. 15
Combined (1) and (2): Total Social Rate Return
In their 2008 study, Medical Research: What's it worth? Estimating the economic benefits from medical research in the UK, the Health Economics Research Group, Office of Health Economics and RAND Europe ('HERG' et al) examine the total social return to the UK that is generated, excluding any health gains, by public or charitable cardiovascular medical research in the UK.[12] They conclude that for every £1 of extra public/charitable research spending in the cardiovascular (or any other) therapeutic area would yield a total social rate of return of at least 20% and perhaps as much as 67%. Using a conservative estimate of 30% as their 'best estimate' of the GDP impact of medical research, this suggests that for every additional £1 invested in cardiovascular research in 2008 the UK's GDP will, after an initial time lag, be 30p higher next year and every year thereafter than it would otherwise have been.[13]

A. 16
Putting this into context, if the £122m (in 2005 price terms) of public and charitable cardiovascular R&D that was invested in 1992 was to yield a 30% rate of return then this would be equivalent to £37m of GDP every year thereafter.[14] A 20% rate of return would therefore yield £24m and a 67% rate of return would yield £82m of GDP every year.[15]

[11] Garau and Sussex (2007)
[12] HERG 2008
[13] HERG 2008
[14] HERG 2008
[15] HERG 2008

Quantification of the Economic Benefits of Spillover

A. 17

Cluster Spillovers: Investment Generating Benefits

In Chapter 4, drawing on CB Richard Ellis' Pharmaceutical Group's benchmarking survey with leading companies in the pharmaceutical sector regarding key attributes for successful R&D locations, we highlight the importance of existing R&D/big pharmas.[16] As Feldman and Audretsch put it, there is "a tendency for innovative activity in complementary industries sharing a common science-base to cluster together in geographic space. Industries which use the same base of scientific knowledge exhibit a strong tendency to locate together for both the location of production and the location of innovation".[17] Such a tendency is not confined to science-based industries but is common to economic activity generally. Economist Paul Krugman, for example, noted a similar tendency in manufacturing, extrapolating from this "that the most striking feature of the geography of economic activity" is its concentration in particular places.[18]

A. 18

This is perhaps surprising given that technological advances mean that global communication is now instantaneous. Feldman and Audretsch, however, distinguish between the transmission of information and that of knowledge. They argue that whereas the costs of transmitting information is unaffected by distance, the costs of transmitting knowledge rises with distance.[19] This is because highly contextual and uncertain knowledge or 'sticky knowledge' is often best transmitted via face-to-face interaction and through frequent contact.[20] Geographical proximity is therefore important to facilitating the spillover of sticky knowledge enabling those working on similar things to benefit from each other's research.[21] Indeed Katz (1994) found that research collaboration within a country is strongly influenced by geographical proximity; as distance increases, collaboration decreases suggesting that face-to-face interaction is key.[22] Commentators generally agree that knowledge spillovers within a specific area thus stimulate further innovation and technological advances as firms and related economic actors and institutions draw productive advantage from their mutual proximity and connections.[23]

A. 19

The economic benefits of this can be seen in multiple ways. The following is discussed in turn below:

- Intellectual property: Patents and licenses;
- Firm performance & growth;
- Start-ups and spin-offs;
- Venture capital; and
- The property sector.

[16] Compton, N. for CB Richard Ellis (November 2009) Global Viewpoint The Pharmaceutical Sector: Real Estate Implications fo Industry-Wide Change
[17] Feldman and Audretsch 1999:411
[18] Krugman, P. (1991a) 'Increasing returns and economic geography' Journal of Political Economy 99:3 pp483- ; Krugman, P. (1991b) Geography and Trade Cambridge: MIT Press cited in Feldman and Audretsch 1999:410
[19] Feldman and Audretsch 1999 drawing on Griliches (1992)
[20] Von Hipple (1994) cited in Feldman and Audretsch 1999
[21] Feldman and Audretsch 1999
[22] Katz (1994) cited in Salter and Martin (2001)
[23] Feldman and Audretsch 1999; The Brookings Institution (2006) Making Sense of Clusters: Regional Competitiveness and Economic Development The Brookings Institution Metropolitan Policy Program

Appendix A
Quantification of the Economic Benefits of Spillover

A. 20
Intellectual Property: Patents and Licences
Intellectual property (IP) is defined as "the patents, trademarks, copyrights and trade secrets owned by a corporation or an individual…As a protected asset, intellectual property has an economic value, similar to real and personal property. It can be sold, licensed, exchanged or gifted [and] its owners can prevent its unauthorised use or sale".[24]

A. 21
Patents tend to be considered the most important IP for life sciences companies and can stimulate economic development in four ways.[25]

A. 22
Patents: Facilitating Technology Transfer and Foreign Direct Investment
In order for a patent to be issued, its details have to be made publicly available.[26] Patent databases are therefore a valuable resource of technical information and can be used to find potential licensors and business partners. This can prove lucrative.

A. 23
The Croatian pharmaceutical company Pliva, for instance, owes much of its success to the discovery of azithromycin, one of the world's best-selling antibiotics. Patented by Pliva in 1980, the drug was subsequently licensed to Pfizer which markets it as Zithromax and sales for which totalled US$1.4bn in 2000 alone. The revenue subsequently accrued by Pliva enabled it to rapidly expand across Croatia, Poland and Russia and it is now widely considered to the largest pharmaceutical company in Central Europe. This only came about, however, because in 1981 Pfizer's scientists happened to come across Pliva's patent when searching through patent documents at the United States Patent and Trademark Office (USPTO).

A. 24
Patents: Innovation at Universities and Research Centres
Publicly-funded R&D can result in inventions, which can then be patented and used to generate revenue for the research centre or university through licensing agreements.[27] This triggers a cycle as the revenues gained enriches the public body so it is able to then fund further R&D.

A. 25
Patents: New Technologies and Industries
Patents can stimulate the creation of new technologies and industries.[28] Biotechnology, for example, would not have developed as it has without the patent system.

[24] Schneider (2002) cited in Mitchell, N. for Young Venture Capital Society (2006) 'The Importance of Intellectual Property in Life Science Ventures and How it impacts Capital Raising' available at <http://www.yvcs.org/uploads/1149278074Life%20Sciences%20Piece_final.pdf>

[25] Mitchell, N. for Young Venture Capital Society (2006) 'The Importance of Intellectual Property in Life Science Ventures and How it impacts Capital Raising' available at http://www.yvcs.org/uploads/1149278074Life%20Sciences%20Piece_final.pdf; World Intellectual Property Organization (no date) 'Intellectual Property- Power Tools for Economic Growth' available at <www.wipo.int/about-wipo/en/dgo/wipo_pub_888/wipo_pub_888_1.htm>

[26] Unless otherwise stated, this sub-section draws on World Intellectual Property Organization (no date)

[27] Unless otherwise stated, this sub-section draws on World Intellectual Property Organization (no date)

A. 26.
Under a licensing agreement with the US-based New England Enzyme Center, the Brazilian laboratory Biobrás began producing enzymes in the 1970s. It then negotiated a joint-venture agreement with patent holders and pharmaceutical multinational Eli Lilly to produce animal insulin in Brazil and receive training from Eli Lilly in R&D, administration and marketing. When the agreement ended in 1983, Biobrás had become an important insulin manufacturer and had branched out into research which led to an important technological breakthrough in the field. It subsequently patented this technology in Brazil, the USA, Canada and Europe. The company is now one of only four pharmaceutical companies, and the only non-multinational, which has the capacity and technology to produce human recombinant insulin.

A. 27
Patents: Accumulation and Revenue Generating Transactions
The patent system stimulates economic development by promoting business activity based on patents.[29] Businesses can benefit from accumulating IP assets and engaging in IP licensing transactions. As the World Intellectual Property Organization (WIPO) puts it, this “can promote competition and create profitable business opportunities that provide jobs, job training, and human resurce development, supply needed goods and services, and increase business and individual income”.

A. 28
It should be noted, however, that using patents as a direct measure of innovative output is often criticised because not all new innovations are patented and because the economic impacts of patents vary hugely.[30]

A. 29
With this is mind, Feldman and Audretsch use the United States Small Business Administration’s Innovation Database (SBIDB) to directly measure innovative product output. This records new product announcements from over 100 technology, engineering and trade journals spanning every industry in manufacturing. The breadth of data is therefore considerable.

A. 30
They conclude that the distribution of innovation within science-based clusters and cities appears to reflect the existence of science-related expertise. Within the biomedical group, for example, Boston, a world-renowned hub of scientific excellence, featured within the top four innovative cities across the United States.[31] This would suggest that clustering positively impacts intellectual property output.

[28] Unless otherwise stated, this sub-section draws on World Intellectual Property Organization (no date)
[29] Unless otherwise stated, this sub-section draws on World Intellectual Property Organization (no date)

[30] Pakes and Griliches (1984) and Griliches (1990) cited in Feldman and Audretsch (1999) economic geography’ Journal of Political
Feldman and Audretsch (1999)
[31] Feldman and Audretsch (1999)

Appendix A
Quantification of the Economic Benefits of Spillover

A. 31
Firm Performance and Growth
A number of papers suggest that geographic proximity and university/public laboratory spillovers are complementary determinants of firms' performance, resulting in significantly higher stock market performance and productivity for private firms[32] The smaller the distance from the nearest university and the higher the number of academic papers published, the higher the growth rate of firms.[33]

"…firms located in the nation and area where academic research occurs are significantly more likely than distant firms to have an opportunity to be among the first to apply the findings of this research"
[Mansfield and Lee (1996) cited in Salter and Martin (2001: 518)]

A. 32
The spillover effects of this are two-fold.[34]

A. 33
On the one hand public R&D improves the productivity of existing private R&D, which in turn results in improved firm performance. Jaffe (1989) showed, for example, that public research indirectly affects private patents by increasing private R&D. Using a 'knowledge production function' he calculated that the overall elasticity of private (or corporate) patents relating to university R&D is around 0.1, meaning that a 1% increase in university R&D is associated with a 0.1% increase in private patents.[35] Together with models of industry R&D and university research which found a even larger associated effect, Jaffe found that the implied elasticity of induced private patents related to university research was almost 0.6.[36]

A. 34
Other studies corroborate Jaffe's findings. Acs et al (1992), for example, analysed actual product innovations in the United States and found even higher elasticities and stronger support for co-location.[37]

A. 35
On the other hand public research can improve firms' performance via a more direct impact on their productivity (i.e. other than impacting existing R&D).[38] Arundel and Geuna (2001), for example, tested the importance of proximity to the transfer of knowledge from publicly funded research organisations (PROs), including universities, to Europe's largest industrial firms. They found that PROs are the most important external source of knowledge for firms' innovation, either through personal contacts, joint research and/or hiring scientists and engineers.[39]

[32] 1
[33] HERG et al (2008)
[34] What follows draws on HERG et al (2008) unless otherwise stated.
[35] Jaffe, A. (1989) 'Real effects of academic research' American Economic Review Vol.79(5) pp957-970 cited in HERG et al (2008)
[36] Jaffe, A. (1989b) cited in HERG et al (2008)
[37] cited in HERG et al (2008)
[38] 1
[39] Arundel, A. and Geuna, A. (2001) 'Does proximity matter for knowledge transfer from public institutes and universities to firms?' SEWP 73 cited in HERG et al (2008)

A. 36
As HERG et al point out, existing literature is unclear as to quite how this competitive advantage occurs but nevertheless shows that it does indeed happen.[40]

A. 37
Start-ups and Spin-offs
Furthermore, modern scientific research tends to result in an entrepreneurial environment whereby new companies are set up to develop findings that could ultimately have a commercial purpose.

A. 38
In such cases the finding body- such as a university or, indeed, UKCMRI- can enter into licensing agreements with companies to use these findings. These companies can be private pharmaceutical companies or, more typically, young start-up biotechs or spin-out companies from universities and other public research institutes.

A. 39
As of 2003, for example, there were fourteen companies in the Boston metropolitan area created in-part or in-whole on technology licensed from Harvard University.[41] Half of these companies were under five years old.[42] Harvard faculty members have also created companies, some of which like Wyeth Genetics Institute and Cambridge Energy Research Associates have subsequently become major regional employers.[43] And Harvard graduates have also established new companies, including Forrester Research, Aquent and Vertex Pharmaceuticals.[44] This ongoing creation of new businesses has been a critical part of the ongoing development of the Boston area economy.[45]

A. 40
Entrepreneurialism thus provides the momentum for existing R&D clusters to grow, creating jobs and boosting economies.

A. 41
Venture Capital
Venture capital investment has traditionally targeted young and fast-growing businesses that demonstrate potential for high return on investment.[46] Historically such investments have funded new technologies and innovations which, being high risk, therefore offer high returns.[47] Leading biotech firms like Genentech and Amgen are examples of companies which have benefited from early-stage VC investment.[48] Consequently, levels of venture capital are often used as a measure of innovation.

[40] HERG et al (2008)
[41] Appleseed Inc for Harvard University (2004) Innovation and Opportunity: Harvard University's Impact on the Boston Area Economy
[42] Appelseed Inc for Harvard University (2004)
[43] Appelseed Inc for Harvard University (2004)
[44] Appelseed Inc for Harvard University (2004)
[45] Appelseed Inc for Harvard University (2004)
[46] DeVol, R., Koepp, R., Wallace, L., Bedroussian, A. and Murphy, D. Milken Institute (2005) The Greater Philadelphia Life Sciences Cluster: An Economic and Comparative Assessment Milken Institute
[47] DeVol, R., Koepp, R., Wallace, L., Bedroussian, A. and Murphy, D. Milken Institute (2005) The Greater Philadelphia Life Sciences Cluster: An Economic and Comparative Assessment Milken Institute
[48] DeVol, R., Koepp, R., Wallace, L., Bedroussian, A. and Murphy, D. Milken Institute (2005) The Greater Philadelphia Life Sciences Cluster: An Economic and Comparative Assessment Milken Institute

Appendix A
Quantification of the Economic Benefits of Spillover

A. 42
In their study of biotechs in the United States, Powell et al found that there is a tendency for venture capital firms to cluster where biotech firms are concentrated.[49] This is to be expected given the nature of venture capital. Given that such investments are high risk, venture capitalists tend to develop a portfolio of investments with different risk-values, timelines and expected pay-offs.[50] This generally requires an extensive contact network as well as the ability to quickly take advantage of new discoveries and research.[51]

A. 43
Moreover, venture capital fuels growth. Kortum and Lerner found that venture capital-backed R&D is three times more likely to generate patents than corporate-sponsored R&D.[52]

A. 44
Intellectual property assets are also important to venture capitalists who typically undertake an IP due diligence audit of a company before deciding whether or not to invest.[53] Companies with strong IP strategies, with a high value IP portfolio and the ability to leverage IP assets into new revenue streams and markets through, for example, licenses, joint ventures and strategic alliances, lead to higher returns.[54]

A. 45
Granted the recent recession is putting pressure on traditional venture capital models, as investors seek to use capital increasingly efficiently and to reduce the time in which profits are realised.[55] Investors are therefore focusing their approach through, for example, asset-centric funding which targets and prioritises the development of single assets,[56] however, rather than cutting off investment altogether. Investors remain central to successful R&D, however, and this has meant. and investors are now increasingly focusing their approach through, for example, asset-centric financing.[57] While this means that venture capital, at least in the traditional sense, may not be the measure of innovation in the future, it nevertheless highlights that more concentrated such investment is nevertheless likely to remain critical to successful R&D.

[49] Powell, W., Koput, K., Bowie, J. and Smith-Doerr, L. (2002) 'The spatial clustering of science and capital: Accounting for biotech firm-venture capital relationships' Regional Studies Vol.36:3 pp291-305
[50] Powell et al (2002)
[51] Powell et al (2002)
[52] Kortum and Lerner (2000) cited in Powell et al (2002)
[53] Mitchell for Young Venture Capital Society (2006)
[54] Mitchell for Young Venture Capital Society (2006)
[55] Ernst & Young (2010)
[56] Ibid.; De Rubertis, F. and Ollier, M. (2010) 'Perspectives for the new normal' in Beyond Borders: Global Biotechnology Report 2010 Ernst & Young (Eds) p7
[57] Ernst & Young (2010)

Appendix A
Quantification of the Economic Benefits of Spillover

A. 46
Real Estate
In its report, Life Sciences Sector Drives Real Estate Growth (2007), Cushman & Wakefield examine trends impacting the life sciences real estate assets in the USA.[58] Its findings show that a mature life sciences sector offers potential real estate investors several industry-specific advantages. These are:[59]

- The life sciences sector has responded to an ageing population, technological advances and increasing levels of drug spending and is now recognised as a driving force in the global economy. This has mitigated many of the risks investors previously associated with life sciences real estate as companies have become increasingly financially stable and R&D funding has increased;
- Life sciences firms generally cluster together in order to benefit from neighbouring firms, research institutions, renowned medical institutions, universities and teaching hospitals and to take advantage of concentrated pools of talented labour. This means that, in some ways, companies are tied to a region and property offering security to investors and landlords that tenants are committed to the areas in which they operate;
- This clustering effect also means that landlords gain proprietary knowledge of tenant activities and demand that 'outside investors' may not have, thereby helping identify opportunities for portfolio expansion and development and helping to determine and underwrite future absorption and vacancy;
- The building requirements of the life sciences sector are very specialised and therefore costly. Indeed the CB Richard Ellis' Life Sciences Group considers it to be some of the most expensive real estate in the world.[60] As a result, tenants usually commit to longer lease terms thereby reducing pressure on a landlord to have to renew the lease every few years and providing a medium to long-term income.

A. 47
Given the above, it is to be expected that the revenue made by the part of the property sector associated with the life sciences is significant.

A. 48
Using data from Real Capital Analytics Inc (RCA), Cushman & Wakefield estimate that the real estate transaction value of life sciences in the USA in 2006 was US$5.1bn.[61] While this only represented 1.5% of the total dollars invested across all property types, they point out that the number of R&D transactions had increased five-fold since 2002 with a 750% increase in the total capital invested and a 467% increase in the number of properties sold.[62] The comparable increase for offices was 119% and 322% respectively.[63]

[58] Cushman & Wakefield (2007) Life Sciences Sector Drives Real Estate Growth New York: Cushman & Wakefield Inc
[59] Unless otherwise stated, this section draws on Cushman & Wakefield's (2007) report.
[60] CB Richard Ellis (2008) Special Report: A Primer on Life Science Properties USA: CBRE Unless otherwise stated this section draws heavily on this report.
[61] Cushman & Wakefield (2007)
[62] Cushman & Wakefield (2007)
[63] Cushman & Wakefield (2007)

Appendix A
Quantification of the Economic Benefits of Spillover

A. 49
San Francisco, one of the USA's key life sciences clusters, provides a more specific example of the life sciences real estate market. Densely concentrated within a 35 mile radius between San Francisco and Palo Alto, this cluster is arguably the global centre of biotechnology, with more than 800 companies estimated to directly employ over 90,000 in the San Francisco Bay area market. Research-related real estate in the area comprises approximately 25 million square feet, making the Bay area the largest life science market in the world.

A. 50
Asking rents for life science new deliveries in San Francisco in 2007 ranged between US$48 and US$60 per square foot on a triple-net basis with an overall build-out allowance averaging between US125 and US$150 per square foot. Existing lab space rates ranged between US$24 and US$42 per square foot with an overall build-out allowance for existing lab space ranging between US$20 and US$50 per square foot.

A. 51
In 2007 the top life sciences sales transactions included Slough Estates (SEGRO) who brought the Slough Estates USA building (5.8m sq ft) from Health Care Properties for US$2.8bn (US$483 per sq ft) and the Raiser Group who purchased the Gateway Technology Center (155,000 sq ft) from Alexander REE for US$71m (US$460 per sq ft).

A. 52
In its report Cushman & Wakefield conclude that life sciences properties will comprise a larger portion of real estate asset allocation in the future.

APPENDIX B

CASE STUDIES

Appendix B
Case Studies

B. 1
The USA
The United States is the world's scientific leader.

B. 2
The think-tank the RAND Corporation estimates it "accounts for 40 percent of total world R&D spending…produces 35 percent, 49 percent, and 63 percent, respectively of the total world publications, citations, and highly cited publications, employs 70 percent of the world's Nobel Prize winners… and is the home of 75% of both the world's top 20 and top 40 universities."[1] Between 2000 and 2004 it issued seven times the number of biotech patents as the next top nine countries combined.[2] This amounts to a total of 5,446 patents compared to 301 for Canada in second place and 134 for the UK in third place.[3] In 2001 it produced 30% of the world's medical devices, double that of Germany, its nearest competitor.[4] Thirty five of its universities occupy the top fifty positions in the percentage share of global biotech publications between 1998 and 2002 and it is a world leader in terms of the availability of venture capital.[5] In 2008, despite the economic crisis, its biotechnology industry raised the second highest amount of venture capital in history (US$4.4bn) having raised the highest (US$5.5bn) in 2007.[6]

B. 3
Government policy has actively sought to develop the US's innovation and R&D capabilities. In 1980 Congress passed two bills to facilitate the commercialisation of publicly funded intellectual property by private firms, enabling scientists to license technologies and create spin-off companies from the public sector.[7] Other bills were passed to allow non-profit organisations, universities and small firms to retain ownership titles to inventions that resulted from federal grants and contracts, and to facilitate the transfer of technologies from the public to the private sector.[8] Such policies have encouraged private business to work in collaboration with public R&D institutes and universities.[9] Key clusters of life sciences research have subsequently developed around Boston, Philadelphia, San Diego, San Francisco, South Carolina and New York.[10]

B. 4
The recent healthcare reform bill, passed in March 2010, is also likely to provide new opportunities to boost the country's R&D. The law includes, for instance, a Qualifying Therapeutic Discovery Project Credit, which is thought biotech companies will be able to access.[11] This offers another funding stream.

B. 5
The Greater Boston area is one of the country's most competitive hubs for life sciences, with an estimated 42,855 life sciences employees, a high concentration of workers with PhDs, a concentration of further and higher education facilities with an estimated student population of 85,000 in 2007/08 and a particularly vibrant medical-devices industry.[12]

[1] Galama, T. and Hosek, J. (2008) US Competitiveness in Science and Technology Prepared for the Office of the Secretary of Defense Santa Monica, CA: RAND Corporation cited in The Royal Society 2010:32
[2] Klowden et al (2009)
[3] Ibid.
[4] Ibid.
[5] Ibid.
[6] Ernst & Young (2009)
[7] Klowden et al (2009)
[8] DeVol, R. and Bedroussian, A. (2006) Mind-to-Market: A Global Analysis of University Biotechnology Transfer and Commercialization The Milken Institute Santa Monica, CA: The Milken Institute cited in Klowden et al (2009)
Klowden et al (2009); Kerber, R. (2004) 'Hub Ranks Top in Life Sciences' The Boston Globe [internet] 8th June available at http://www.boston.com/business/technology/biotechnology/articles/2004/06/08/hub_ranks_top_in_life_sciences/ [accessed 24th May 2010]
[10] Ibid.; CB Richard Ellis (2008) Special Report: A Primer of Life Science Properties USA: CB Richard Ellis
[11] Ernst & Young (2010)
[12] Ibid.

B. 6
California, however, is traditionally seen as the country's life sciences leader with clusters in San Diego and around San Francisco.[13] Here leading pharmaceutical and biotechs concentrate, including two of the country's largest biotech firms, Genentech Inc and Amgen Inc.[14] Furthermore, the University of California (UC) is a global research leader as demonstrated by three of its universities, UC- San Francisco, UC-Los Angeles and UC-San Diego, being ranked within the top ten universities in the world for biotechnology publications between 1998 and 2002.

B. 7
As the Milken Institute points out in its 2009 report, The Value of US Life Sciences, those states with particularly strong life science clusters include world-renowned research universities. It concludes that "[l]ife sciences industries thrive in regions that have institutions and policies in place that effectively transfer technologies from universities to the commercial marketplace" and that "[u]niversities play important roles in R&D as well as technology transfers, which bring scientific innovation to commercialization".[16] For example, in an effort to boost R&D and tech-transfer the Florida High-Tech corridor in the Tampa Bay region has established grant-matching programs with neighbouring universities such as the University of Central Florida, the University of Southern Florida and the University of Florida.[17]

B. 8
Similarly, many of the country's leading life sciences clusters, such as Philadelphia, Boston and San Diego, include elite medical schools. This has prompted Orlando to build a new College of Medicine at the University of Central Florida, which is predicted to, within a decade, generate a regional economic impact worth $1.4bn through wages, employment and output.[18]

B. 9
The USA is also home to the world's largest, private non-profit biomedical research facility, The Scripps Research Institute.[19] Established in 1961 in La Jolla, California, it provides research facilities for circa 2,800 staff including 289 faculty members, nearly 815 postdoctoral fellows, 235 postgraduate students and over 1,500 technical and administrative support roles.[20] The Institute is located near to the University of California- San Diego, as well as San Diego's scientific community which includes The Salk Institute, the Burnham Institute and some 300 biotech companies, many of which constitute spin-off companies.[21] A second Institute was later established in Jupiter, Florida adjacent to Florida Atlantic University.[22]

B. 10
Scientists working at the Institute undertake basic research into immunology, molecular biology, cell biology, chemistry, autoimmune diseases, cardiovascular disorders and cancer with the intention of making drug discoveries.[23] Multi-disciplinary collaboration is strongly encouraged and the Institute serves as a model for scientific work throughout the USA and the rest of the world.

[13] Kerber (2004)
[14] Ibid.
[15] Klowden et al (2009)
[16] Klowden et al (2009: 11)
[17] Klowden et al (2009)
[18] Wong, P. and Bedroussian, A. (2006) Economic Benefits of Proposed University of Central Florida College of Medicine The Milken Institute Santa Monica, CA: The Milken Institute cited in Klowden et al (2009)
[19] The Scripps Research Institute (n.d.) 'Facts-at-a-Glance' The Scripps Research Institute www.scripps.edu/intro/facts.html [accessed 24th May 2010]
[20] Ibid.
[21] The Scripps Research Institute (n.d.) 'About TSRI' The Scripps Research Institute http://www.scripps.edu/intro/overview.html [accessed 24th May 2010]
[22] Ibid.
[23] Ibid.

B. 11
However the USA's global dominance in the life sciences is being challenged. Its percentage share of the world's medical devices exports has dropped since 2001 as shares for Germany, Ireland, the Netherlands and Mexico have increased.[24] Its percentage share of pharmaceutical exports has similarly dropped, whereas shares for Switzerland and Germany's have increased.[25] And mid-career US-based scientists are increasingly migrating to, or returning home to, countries like Singapore and China where scientific opportunities are growing.[26] Thus while the United States is undoubtedly a global leader in the life sciences, its position is being challenged.

B. 12
That said, with President Obama having recently increased his Government's investment in R&D, and basic science especially, as part of an economic stimulus package (see Chapter 3), it seems that America is ready to defend its global dominance in the life sciences.

B. 13
Emerging Economics
So-called emerging economies around the world are also targeting science and innovation, notably China, Singapore, India and Brazil.

B. 14
It should also be noted that, while most industrialised and many developing countries have been negatively impacted by the global recession, economic growth in some emerging economies such as China and India has continued to increase.[27]

B. 15
China
China has enormous potential for growing its R&D sector and it is becoming an increasingly strong competitor in the fields of science and innovation as it seeks to become an innovation-oriented nation.

B. 16
Since 1999 the country's R&D spending has increased by nearly 20% per annum and it is now the world's second largest R&D investor after the US.[28] In 2006 the Chinese government approved a fifteen year plan for science and technology which will require six times the investment of 2005 by 2020.[29] And biomedicine is identified as a strategic focus in the Government's Five-Year Plan (2006-2010) and expected to be a targeted industry in the subsequent Five-Year Plan.[30]

B. 17
The State Food and Drug Administration (SFDA) has also implemented a fast-track approval process for new drug approvals and the Government is reforming its patent laws to strengthen its intellectual property protection.[31]

[24] Klowden et al (2009)
[25] Ibid.
[26] Hyman, S. (2008) 'US Science Policy needs to Heed Global Realities' ScienceNews [internet] 24th May available at http://www.sciencenews.org/view/generic/id/32457/title/Comment__U.S._science_policy_needs_to_heed_global_realities [accessed 24th May 2010]
[27] Ernst & Young (2010) Beyond Borders: Global Biotechnology Report 2010 Global Life Sciences Center: Ernst & Young
[28] OECD 2006 (Press Release) China will become the world's second highest investor in R&D by end of 2006, finds OECD Paris: Organisation for Economic Co-operation and Development 4th December cited in The Royal Society (2010)
[29] PRC State Council (2006) Guidelines for the Medium and Long Term National Science and Technology Development Programme 2020 Beijing: People's Republic of China State Council
[30] Ernst & Young (2010)
[31] Ibid.

B. 18
In 2009 the Government also extensively reformed the country's healthcare system, committing RMB850bn over three years to increase health insurance coverage.[32] This will lead to higher pharmaceutical sales and steps are already being taken to improve China's drug distribution system.[33]

B. 19
Science parks have also been developed across the country. This includes China Medical City in Jiangsu, Shanghai Zhanjiang Hi-Tech Park, home to nearly 100 companies, and Beijing Zhongguancun Life Science Park, which has attracted many world-leading life sciences companies because of its proximity to renowned universities like Peking University and Tsinghay University.[34]

B. 20
This high level of investment, legal reform and the building of infrastructure is already having results.

B. 21
China's output of peer-reviewed papers is now 64 times that of 1981, meaning that it is projected to become the world's leading producer of scientific publications by 2020, and in 2008 it achieved 4% of the world's highest impact research papers.[35]

B. 22
In addition, the proportion of pharmaceutical patents naming Chinese researchers has quadrupled since 1995.[36] And, whereas in 2001 the country was home to fewer than 100 R&D centres, by 2005 this had increased to more than 700.[37]

B. 23
Furthermore, China is expected to become the third-largest drug market in the world by 2011, behind the USA and Japan.[38]

B. 24
China's biggest challenge, however, is strengthening its domestic technology and research base and substantially growing the share of domestically-owned intellectual property. Its Government is concerned, for example, that 80% of the intellectual property involved in China's exported high technology goods and services is owned by non-Chinese companies and has thus taken steps to improve its intellectual property laws.[39]

B. 25
But China has a vast domestic labour resource, both existing and in terms of future potential. It is home to 926,000 researchers, second only to the US.[40] And in 2004 alone it produced 6.5 million undergraduates and 500,000 postgraduates in science, medicine and engineering.[41] Furthermore, its 'sea-turtle' population- Chinese-born nationals who study and spend the early part of their careers in Western countries- are increasingly returning home.[42] Given its successes to date, if its labour resources can be better utilised in the future, then China's potential within the life sciences sector is hugely significant.

[32] Ernst & Young (2010)
[33] Ernst & Young (2010)
[34] Ernst & Young (2010)
[35] Adams, J., King, C. and Singh, V. (2009) Global Research Report: India Research and Collaboration in the New Geography of Science Leeds, UK: Evidence (a Thomson Reuters company) cited in The Royal Society (2010); Council of Science and Technology (2010)
[36] The Royal Society (2010)
[37] Ibid.
[38] Ernst & Young (2010)
[39] Council of Science and Technology (2010); Ernst & Young (2009)
[40] Ibid.
[41] Council of Science and Technology (2010)
[42] Ernst & Young (2009)

B. 26
Singapore
In light of falling returns from its electronics sector, since 2000 Singapore has sought to diversify its economy to include research-intensive biotechnology. Billed as the gateway to Asian markets and renowned for its liberal approach to stem cell research, Singapore is now one of the world's leading hubs of scientific excellence.

"Singapore could and should be a model for other nations that are trying to build biomedical research capacity."
D. Cyranoski in Nature (July 2001)

B. 27
It is considered an attractive R&D location in part because of its robust regulatory frameworks and adherence to global standards of safety, quality and efficacy.[43] In January 2010 it was added to the OECD's 'Mutual Acceptance of Data' framework under which data generated in preclinical trials in compliance with good laboratory practices is deemed acceptable in 30 OECD and non-OECD member states.[44] And the World Economic Forum's Global Competitiveness Report 2009- 2010 gave it a top rating for its intellectual property protection.[45]

B. 28
Its success is in part due to supportive government policy such as the National Biomedical Science Strategy and tax incentives for foreign companies seeking to locate within Singapore.

B. 29
Funding too has played a contributory role. Singapore officials estimate that they spent US$949 million on biotechnology between 2000 and 2006 with another US$1.44 billion budgeted to finance the development of new therapies and drugs between 2006 and 2011.

B. 30
But Singapore has also provided the infrastructure necessary to encourage the biotechnology sector to flourish.

B. 31
Central to this has been Biopolis, a high-tech seven-building biomedical park that opened in 2004 and is described as Asia's leading centre for biomedical sciences and R&D. It is home to several government agencies, publicly funded research institutes, and the R&D laboratories of pharmaceutical and biotech companies. These include five of the government's Agency for Science, Technology and Research's (A*STAR) Biomedical Research Institutes as well as Johns Hopkins in Singapore, Novartis, GlaxoSmithKline and Isis Pharmaceuticals. It is also located close to the National University of Singapore, National University Hospital and the Singapore Science Parks. Scientists working at Biopolis are encouraged to interact and work collaboratively across multiple disciplines.

[43] Ernst & Young (2010)
[44] Ibid.
[45] Ibid.

B. 32
Foreign experts are migrating to Singapore and working at Biopolis. For example, leading British scientist Alan Colman who helped clone Dolly the sheep in the mid-1990s is now a Principal Investigator in the A*STAR Institute of Medical Biology and also Executive Director of the Singapore Stem Cell Consortium. And British oncologist Professor Sir David Lane, who discovered the p53 tumour-suppressing gene, is currently Executive Director of Singapore's A*STAR Institute of Molecular and Cell Biology. Notably, both individuals have been critical of what they perceive to be Britain's declining competitiveness in their respective fields.

B. 33
Furthermore, Biopolis is now the centre of a countrywide research network including leading medical institutes, public hospitals and other research facilities.[46]

B. 34
Financial returns to Singapore's economy from its scientific endeavours have been considerable. Factory pharmaceutical production alone now accounts for over 5% of Singapore's economy, amounting to approximately US$11.4 billion in annual revenue. And in 2001 direct foreign investment in the biomedical sector was 6% greater than in 2000 at US$48.3 million.

B. 35
However, Singapore historically lacks the entrepreneurial environment to nurture biotechnology start-ups and there are concerns about its lack of human capital.[47] For example, a joint venture at Biopolis between John Hopkins University and Singapore's top scientific agency closed because the agency said John Hopkins was falling short of its recruitment goals.

B. 36
Nevertheless, it remains the case that in a mere decade Singapore has been hugely successful in developing a globally competitive biotechnology sector that attracts world renowned scientists, capital investment and the presence of multinational pharmaceutical companies.

B. 37
Europe
Whereas the UK has traditionally led Europe in life sciences, it is facing increasing competition as other European countries seek to increase their share of this market.

B. 38
Comparing European public pipeline growth rates illustrates this well. While in 2006 the UK's public pipeline growth rate for biotech products grew by 16%, its growth curve flattened in comparison to previous years.[48] This is partly because of acquisitions that had occurred that year but it should also be noted that, although the UK continued to top European country rankings overall, Sweden's public pipeline growth increased by 44%, Denmark's by 46% and Germany's doubled.[49] Not only are other European countries looking to increase their market share in the life sciences, but growth rates have been rapid.

[46] Ernst & Young (2010)
[47] Normile, D. (2002) 'Can money turn Singapore into a biotech juggernaut?' Science 30th August Vol.297:5586 pp1470-1473
[48] Ernst & Young (2007) Beyond Borders: Global Biotechnology Report 2007
[49] Ibid.

B. 39
Germany
Germany's biotechnology sector grew significantly during the 1990s following the introduction of new Government policies. These were intended to boost the development of small entrepreneurial firms and make Germany Europe's 'number one' in biotechnology.[50] As a result the number of new biotech start-ups quadrupled from 75 in 1995 to over 300 by 1998. Furthermore, between 1995 and 1996 alone the total revenue and workforce of small and medium-sized biotech firms nearly doubled, growing much faster than either the European or American average.[51]

B. 40
The country's biotech sector has continued to grow, with the largest clusters located in Berlin and Munich.[52] In 2006 almost 400 biotech companies, the largest share in Europe, employed nearly 10,000 people.[52] As Ernst & Young highlight, in addition to enabling technologies and drug discovery services these companies are increasingly developing therapeutic and molecular diagnostic products, reflecting the innovative power of biotech concentrations.[54] Given this it is perhaps to be expected that Germany leads Europe in terms of the number of private biotech products in development. [55]

B. 41
France
As part of its wider strategy for improving France's economy, since the late 1990s the French Government has specifically targeted industry competitiveness and R&D-led innovation with its competitiveness cluster initiative.[56] This seeks to bring together companies, research centres and educational institutes to work collaboratively and strengthen France's economy in respect of, inter alia, biotechnology.[57]

B. 42
As part of this, the Government has selected seven biotech and life sciences clusters across the country including two global competitiveness clusters, Lyonbiopôle and Medicen Paris Region. [58]

B. 43
In 1998 the French Ministry of Research and Higher Education and several regional and local authorities, together with the University of Evry Val-d'Essonne (UEVE) and the French Muscular Dystrophy Association (AFM), established Genopole, just south of Paris.[59] Modelled on world-class North American and European bioclusters, this was the country's first ever science and business park dedicated to genomics, post-genomics and biotechnology.[60] It aims to ensure France's global competitiveness in these fields and sought to bring together public and private research laboratories, university teaching facilities and life science start-ups.[61]

[50] Casper, S. (2000) 'Institutional Adaptiveness, Techology Policy, and the Diffusion of New Business Models: The Case of German Biotechnology' Organisation Studies Vol.21:5 pp887-914; Adelberger, K. (2000) 'Semi-sovereign leadership? The state's role in German biotechnology and venture capital growth' German Politics Vol.9:1 pp103-122
[51] Ibid.
[52] Ernst & Young (2007b) European Country Profiles: A Supplement to Beyond Borders: Global Biotechnology Report 2007 London: Ernst & Young
[53] Ibid.
[54] Ibid.
[55] Ernst & Young (2007a)
[56] General Directorate for Competitiveness, Industry & Services (France) (2009) 'Competitiveness Clusters in France' Ministère de l'Économie [internet] 17th February available at http://www.industrie.gouv.fr/poles-competitivite/brochure-en.html [accessed 24th May 2010]
[57] Ibid.
[58] Ernst & Young (2007b)
[59] Genopole (n.d.) www.genopole.fr [accessed 24th May 2010]
[60] Ibid.

B. 44
Genopole provides 87,298 sq m of real estate, has 2,293 employees and is home to 69 biotech companies and 20 academic research laboratories. More than 670 patents have been filed by campus companies and the 35 companies in Genopole's portfolio have cumulative earnings of €144,11m.

B. 45
As its infrastructure matures and product pipelines advance, France is reaping the benefits of its investments. In 2006, for the first time ever, France topped Europe in terms of venture funding of biotech companies, with the capital raised having increased by nearly 60% from €153m in 2005 to €242m in 2006.[62] As venture capital for the UK also grew, but the increase was nowhere near as large.

B. 46
President Sarkozy has committed his Government to significant investment in the sciences in the wake of the global recession (see Chapter 3). It would appear that the French Government is actively seeking to build on its successes to date.

B. 47
Spain
Although currently only ranked 9th in the world for the number of science publications, and 20th in terms of impact, Spain is looking to science as a means of resolving its economic difficulties following the recession and the collapse of its real estate market.[63]

B. 48
Barcelona Biomedical Research Park (PRBB)
In 2008 the Government created the Science and Innovation Ministry and earlier in 2010 Science and Innovation Minister Cristina Garmendia outlined proposals for Spain's new 'Science law'.[64] This seeks to reward scientific talent, encourage entrepreneurship and will create a new Spanish research agency to oversee scientific spending and encourage public-private R&D partnerships.[65]

B. 49
Already Spain is developing modern scientific infrastructure to encourage scientific innovation and research.

[61] Ibid. The following statistics are also taken from the Genopole website, unless otherwise stated.
[62] Ibid.
[63] Regalado, A. (2010) 'Spain turns to Science for Stimulus' ScienceInsider [internet] 12th March available at http://news.sciencemag.org/scienceinsider/2010/03/spain-turns-to-science-for-stimu.html [accessed 24th May 2010]
[64] Ibid.
[65] Ibid.
[66] Parc Recera Biomèdica de Barcelona (n.d.) 'Barcelona Biomedical Research Park' www.prbb.org [accessed 24th May 2010]
[67] New Statesman (2010) 'Celgene opens European R&D hub for translational research' NewStatesman [internet] 26th February available at www.newstatesman.com/healthcare-and-pharmaceuticals/2010/02/research-celgene-european [accessed 24th May 2010]; Philippidis, A. (2010) 'Celgene opens translational

B. 50
The Barcelona Biomedical Research Park (PRBB) opened in 2006 and offers state-of-the-art facilities for biomedical research. It is a joint venture between the Catalonian Government, Barcelona City Council and Pompeu Fabra University (UPF) and is designed to encourage a multi-disciplinary approach to research. The building is physically connected to the Hospital del Mar de Barcelona and includes public research centres like the Centre of Regenerative Medicine as well as pharmaceutical companies like GlaxoSmithKline. Approximately 1,200 staff work at the Park and it bills itself as one of the largest biomedical research clusters in Southern Europe.[66]

B. 51
Earlier in 2010 the Celgene Institute of Translational Research Europe (CITRE) opened in Seville, Spain.[67] This is intended to bridge the gap between basic and clinical research by bringing together industry, academia and government and will concentrate specifically on biomedical research, regenerative medicine, personalised medicine and stem-cell research.[68] It will employ leading scientists from around the world and aims to become a European hub for cutting edge translational research.[69] It will also co-ordinate and manage Celgene’s medical research throughout Europe.[70]

B. 52
Thus while Spain currently lags behind its European neighbours in the life sciences, it is actively challenging this status quo.

science hub in Spain’ 1st GenomeWeb Daily News [internet] 1st March available at www.genomeweb.com/celgene-opens-translational-science-hub-spain [accessed 24th May 2010]
[68] New Statesman (2010)
[69] ecancermedicalscience (2010) ‘Celgene Institute of Translational Research Europe launched in Spain’ ecancermedicalscience [internet] 26th February available at www.ecancermedicalscience.com/cache/pdf/news-943.pdf [accessed 24th May 2010]
[70] Ibid.

APPENDIX C

ECONOMIC BENEFITS OF A HEALTHY WORKFORCE

Appendix C
Economic Benefits of a Healthy Workforce

C. 1
A Healthy Workforce: Investment Saving Benefits
Chronic diseases are an economic burden. They cost money in terms of treatment but also with regard to productivity loss. As the Milken Institute points out in its analysis of chronic disease in the United States, chronically ill people take sick days ('absenteeism'), thereby reducing labour supply and, in the process, GDP.[1] Even when chronically ill people do go to work, they tend to perform less efficiently than they would do if they were healthy ('presenteeism').[2] In fact output loss from presenteeism is far greater than losses associated with absenteeism.[3] And there is also the loss of productive capacity for caregivers to consider.[4]

C. 2
Investing in life sciences can save money by developing new medical treatments which either reduces the overall cost of treatment per patient or the number of patients that need to be treated.

C. 3
Coronary heart disease is the leading cause of death in the UK. Liu et al estimate that, in 1999, it cost £1.73bn to the UK's healthcare system, £2.42bn in informal care and £2.91bn in friction period adjusted productivity loss, meaning the period an employee is absent from work before an employer replaces them with other workers.[5] The total annual cost of coronary heart disease in the UK is therefore estimated to be £7.06bn.[6]

C. 4
Saka et al estimate the cost of strokes to the UK economy looking at both direct costs, including diagnosis, in- and out-patient care, and indirect costs like income loss and social benefit payments to stroke patients.[7] They found that treatment and productivity loss arising from strokes cost society £8.9bn per year.[8] Direct costs accounted for 50% of this total, informal care for 27% and indirect costs 24%.[9]

C. 5
Cancer is the second largest cause of death in the UK.10 More than one in three people will develop some form of cancer during their lifetime and it is responsible for one in four deaths in the UK.[11] Incidence rates are increasing by around 1.5% per annum and approximately 5% of annual NHS spend is on cancer, amounting to about £76 per head in England and £4.5bn in total.[12] In 2008 cancer is estimated to have cost £18.33bn in England alone. This is expected to increase to an estimated £24.72bn by 2020, including an £18.18bn estimated loss in productivity.[13]

[1] Milken Institute (2007) An Unhealthy America: The Economic Burden of Chronic Disease DeVol, R. and Bedroussian, A.
[2] Milken Institute (2007)
[3] Milken Institute (2007)
[4] Milken Institute (2007)
[5] Liu, J. Maniadakis, N., Gray, A. and Rayner, M. (2002) 'The Economic Burden of Coronary Heart Disease in the UK' Heart V.88 pp597-603
[6] Liu et al 2002
[7] Saka, O., McGuire, A. and Wolfe, C. (2009) 'Cost of Stroke in the United Kingdom' Age and Ageing V.38(1) pp27-32
[8] Saka et al (2009)
[9] Saka et al (2009)
[10] Featherstone, H. and Whitham, L. (2010) 'The Cost of Cancer' Policy Exchange: Research Paper
[11] Cancer Research UK (2009) 'Cancer in the UK' available at http://info.cancerresearchuk.org/cancerstats/; Featherstone, H. and Whitham, L. (2010) 'The Cost of Cancer' Policy Exchange: Research Paper
[12] Cancer Research UK 2008 'NCRI Session- the Cost of Cancer Care' <http://scienceblog.cancerresearchuk.org/2008/10/21/ncri-session-the-cost-of-cancer-care>
[13] Featherstone and Whitham (2010)

Appendix C
Economic Benefits of a Healthy Workforce

C. 6
All other things being equal, the costs associated with chronic disease will grow because people are living longer with average life expectancy increasing by more than five hours a day every day.[14] This is partly due to new pharmaceutical products. In his study of the impact of new drugs on health and economics in the United States, for example, Lichtenberg reports that the average new drug approval increases the life expectancy of the people born in the year the drug is approved by 5.8 days.[15]

C. 7
Age is, however, the single greatest risk factor for many life-threatening diseases.[16] A tumour is one hundred times more likely to occur at 65 than at 35 years old and 74% of all new cancer cases in the UK occur in people aged over 60 years old and more than a third of these are over 75.[17] This is not only significant in terms of potential increases in the numbers of those affected, but also in terms of recovery. Research shows that whereas 74% of cancer survivors aged under fifty return to work, only 30% of survivors over fifty do the same.[18] This represents a loss of productivity and the Academy of Medical Sciences predicts that by 2020 the demographic shifts caused by the UK's ageing population is going to cost the Government nine times more than the current economic downturn.[19]

C. 8
Reducing the economic burden of chronic disease is undoubtedly complicated and involves many contributory factors such as improved health-behaviour, prompt diagnosis and, in the UK specifically, boosting its relatively poor uptake of new treatments and technologies.[20] However evidence suggests that new pharmaceutical products not only extend life expectancy but also reduce demand for other types of medical care.

C. 9
The Department of Health estimates that some 10,000 lives are saved annually by statins, which are used to reduce cholesterol and therefore lower the risk of angina, heart disease and strokes.[21] Indeed, deaths from heart disease and strokes fell by 44% between 1997 and 2007, in part because of statins are more widely prescribed.[22]

In the USA, the Boston Consulting Group found that operations for peptic ulcers decreased from 97,000 in 1977, when H2 antagonists like Zantac and Tagamet were introduced, to 19,000 in 1987 saving US$224m in yearly medical costs.[23]

C. 10
Murphy and Topel (2003) estimate that the total economic value to Americans of reductions in mortality from cardiovascular disease averaged US$1.5 trillion per annum between 1970 and 1990.[24] In economic terms, if just one-third of this gain came from medical research, the return on investment averaged US$500bn annually.[25]

[14] The Academy of Medical Sciences (2009) Rejuvenating Ageing Research
[15] Lichtenberg, F. (2003) The Value of New Drugs: The Good News in Capsule Form' Fourth Quarter pp17-25
[16] The Academy of Medical Sciences (2009) Rejuvenating Ageing Research
[17] Featherstone and Whitham (2010); Cancer Research UK (2009) 'Cancer in the UK' available at <http://info.cancerresearchuk.org/cancerstats/>
[18] Spelten, E. et al 'Factor reported to influence the return of cancer survivors: a literature review' Psycho-oncology V.11 pp124-131 cited in Featherstone and Whitham (2010)
[19] The Academy of Medical Sciences (2009)
[20] Featherstone and Whitham (2010)
[21] Hudson, C. (2009) 'Statins: Life-saving wonder-drugs or just life-damaging?' The Telegraph 4th May 2009
[22] Laurence, J. 'The Big Question: Are Statins really a Wonder Drug, and should we all be taking Them?' The Independent 11th November 2008
[23] Lichtenberg (2003)

Appendix C
Economic Benefits of a Healthy Workforce

C. 11
Also in America, Funding First reports that the development of lithium for the treatment of manic depressive illness results in health cost savings of more than US$9m annually and that a 17-year programme which invested only US$56m in research on testicular cancer resulted in a 91% cure rate and annual savings of US166m.[26]

C. 12
Admittedly studies of potential savings yielded by particular drugs have had
mixed results and it sometimes unclear whether the long-term savings outweigh the costs of administering expensive drugs or are, indeed, the result of pharmaceutical products. Having collated data about the utilisation of pharmaceuticals, ambulatory care and hospital care in the USA in 1980 and 1991 or 1992 Lichtenberg found, for example, that a US$ 1 increase in pharmaceutical expenditure could have led to a US3.65 reduction in hospital care expenditure, ignoring any indirect cost of hospitalisation.[27] But this reduction might also have been because of a US$1.54 increase in expenditure on ambulatory care.[28]

C. 13
Nevertheless, in a second US-based study, Lichtenberg found that, while new drugs tend to increase prescription costs by an average of US$18, replacing an old drug also reduced the number of hospital stays by about six fewer stays per thousand prescriptions.[29] Allowing for the fact that hospital stays associated with newer drugs are typically shorter, as well as fewer, this meant an average reduction in hospital expenditure of US$56, thereby far outweighing the increase in prescription costs.[30]

C. 14
It should also be noted that calculating health gains from medical research is also shaped by the methodology used. A popular approach, called the ‘top down’ approach by HERG et al (2008), value health gains from reduced morbidity and mortality at the macro level and then draw conclusions as to the proportion that can be attributed to medical research.[31]

C. 15
HERG et al, however, use a ‘bottom-up’ approach that looks at specific interventions to make assumptions about the value of health gains to treat or prevent cardiovascular disease.[32] They therefore use quality adjusted life years (QALYs) from 46 combinations of patient groups and specific interventions treat or prevent cardiovascular disease in the UK between 1985 and 2005. These QALYS are valued at £25,000, which is the mid-point of the threshold used by the National Institute for Health and Clinical Excellence (NICE), and represent a measure of the opportunity cost if, rather than investing in R&D, the resources had been used directly in the NHS. HERG et al subsequently conservatively estimate that the value of QALYs gained from the specific interventions is £69bn and could be as much

[24] Funding First (2000) in 1 This research suggested that individuals’ average willingness to pay for small reductions in the risk of death is equivalent to a value of around US$5m to prevent a fatality or gain a ‘statistical life’.
[25] Funding First (2000) in 1 In considering the proportion of gains which can reasonably be attributed to medical research, the authors cited evidence that one third of the decline in cardivascular disease mortality is due to invasive treatment, one third to pharmaceuticals and one-third to behavioural changes.
[26] Funding First (2000) Exceptional Returns: The Economic Value of America’s Investment in Medical Research New York: Funding First
[27] Lichtenberg (2003)
[28] Lichtenberg (2003)
[29] Lichtenberg (2003)
[30] Lichtenberg (2003)
[31] HERG et al (2008)
[32] HERG et al (2008)

as £91bn. For the same period they estimate that the total incremental health care costs relating to those gains to be £16bn. The monetary gains from increased life expectancy therefore far outweigh the associated increases in healthcare costs.

C. 16
Furthermore, Murphy and Topel show that improvements in health compliment one another.[33] In other words, advances against one disease, such as heart disease, raise the economic value of progress against other diseases, like cancer.[34]

C. 17
Yet, as outlined above, chronic disease is expensive and looks set to become increasingly expensive as people live longer and thus become increasingly susceptible to disease. But what the above also indicates is that scientific research and successful drug discoveries can significantly reduce these costs.

C. 18
If survival rates for cancer in England improved to levels commensurate with the best in Europe, then it is estimated that, by 2020, 71,500 lives would have been saved and the total costs of cancer to the UK would be reduced by £10bn. [35]

C. 19
Murphy and Topel (1999) estimate that eliminating deaths from heart disease in the USA would generate circa $48 trillion in economic value while a cure for cancer would be worth circa $47 trillion. Even a 1% reduction in cancer mortality would be worth about $500billion.[36] They add that reducing the age-specific death rate from AIDS would be worth about US$750bn.[37]

C. 20
Using a similar methodological approach and attempting to estimate the returns to investment for research undertaken in Australia for each main disease area, Access Economics found that for each year of life lost due to premature mortality there was a further 86% of a 'disability adjusted life year' (DALY) lost due to disability, worth AUS$129,000. They subsequently concluded that "health R&D has directly, indirectly or serendipitously accounted for at least half of the gains" of which they estimated that 2.5% of the health benefits attributable to health research were attributable to Australian research.[38]

C. 21
The potential economic savings from medical research are clearly significant. There is also something to be said for the potential economic gains to be had by whoever it is that owns the intellectual property rights to a pharmaceutical product that successfully treats, for example, heart disease or cancer. This is all the more significant given that, in 2009, several countries have passed healthcare reforms, notably the USA and China.[39] While the precise implications of this are as yet unknown, increased insurance coverage in the US, for example, will boost demand for drugs.[40]

[33] Murphy and Topel (2003)
[34] Murphy and Topel (2003)
[35] Featherstone and Whitham (2010)
[36] Murphy and Topel (1999)
[37] Murphy and Topel (1999)
[38] Acess Economics 2003: 62 cited in 1:12
[39] Ernst & Young (2010)
[40] Austin, C. (2010) 'Reforming US Health Care' in Beyond Borders: Global Biotechnology Report 2010 Ernst & Young (Eds) p12

APPENDIX D

INDUCED OR CONSUMPTION IMPACTS: THE INCOME MULTIPLIER EFFECT

Appendix D
Induced or Consumption Impacts: The Income Multiplier Effect

D. 1
Any organisation that engages in commercial transactions, such as paying wages to its employees, will have some impact on the local economy. Direct impacts such as locally sourced labour and the use of local suppliers and contractors have already been considered in Chapter 5. Here attention turns to induced or consumption impacts, meaning the amount of spending by employees in local communities and the effects on other business activity. This is also called the income multiplier effect.

D. 2
Relevant studies do not address this within the context of R&D facilities. This section therefore draws on the general theories set out in papers looking at the effects of induced or consumption spending in other sectors.[1]

D. 3
Employees will usually spend a proportion of their wages within the local area of their place of work. In turn, this spending triggers secondary, tertiary (etc) expenditure that filters through the local economy and increases overall expenditure by a much greater amount than is initially spent.

D. 4
Looking at the economic impact of healthcare facilities on communities, McDermott et al state that employees spend between 30-40% of their salaries on purchases within the local community.[2] Assuming that an employee's monthly paycheck is US$1,000, they assume that that employee will spend US$400 on goods and services from local businesses. Those businesses in turn spend 40% of the funds they receive from the employee on local suppliers, which McDermott et al calculate to be US$160. Local suppliers then spend 40% of their funds with the local community, which McDermott et al calculate to be US$64. The initial US$400 spend therefore stimulates the local economy by a total of US$624.

D. 5
It is difficult to assess the level of induced or consumption impacts that will result from UKCMRI or, indeed, any one specific business regardless of sector. While McDermott et al's calculation demonstrates the potential cumulative effects of supply and demand, its approach is nevertheless simplistic. In reality the impacts depend on multiple factors such as the size of the organisation and the amount of money that an employee spends within any one local economy. Expenditure is not only likely to be split between several businesses but will also depend on that employee's individual circumstances. Spend is likely to be higher, for instance, and thus the overall contribution to the local economy will be higher, for a scientist who both lives and works in Camden than it would be for one who commutes to UKCMRI from outside the Borough.

D. 6
There will also be expenditure leakage outside of the local economy and it should be noted that increases in local expenditure are not infinite, but will eventually dissipate depending on leakage levels.

[1] This section therefore draws heavily on the following: McDermott, R., Parsons, R. and Cornia, G. (1994) 'Calculating the Economic Impact of Healthcare Facilities on Communities' Healthcare Financial Management: and Weller, G. and Parsons, R. (2002) Assessing the Community Economic Impact of Microfinance Institutions' available at <www.microfinancegateway.org>
[2] McDermott et al (1994)