

Stem Cell Monitoring and Evaluation Framework

Final report

October 2008

1: Introduction

Overview

- 1.1 The Scottish Stem Cell Intervention Framework (SCIF) is a collaborative effort, supported by the Scottish Government, Scottish Enterprise, Scottish universities, private companies and individuals, to establish Scotland as one of the leading world locations for stem cell activity. The Intervention Framework and its subsidiary projects have grown in an organic fashion over the period from 2003 to the present.
- 1.2 Current research is focused on the ability of stem cells to develop into many different types of specialised cells, offering the potential to regenerate human tissue and help treat a wide range of medical conditions. There are many barriers to achieving this – scientific, technical and commercial. Currently the private sector has had only limited involvement, with major investors cautious about entering a field whose commercial returns remain to be demonstrated and where a clear business model does not yet exist. SE and other partners have launched the SCIF to help close this information gap and to support the translation of stem cell research through into successful therapies, products and services.
- 1.3 SQW Consulting (SQWC) was commissioned to develop a monitoring and evaluation framework for the SCIF, to meet internal needs for performance management and to give partners a framework for measuring progress. The study consisted of two tasks: to develop a consistent monitoring and evaluation framework for the family of projects in the Intervention Framework, and to develop a method whereby some assessment could be made of Scotland's progress in this field against national and international comparators.
- 1.4 While this study is not a formal evaluation of the projects being supported within the Intervention Framework, it has been a useful staging point to take stock of progress to date, and to consider how to achieve partner objectives in the future. In this regard, the national and international comparators strand of the study has played an especially useful role in informing the approach to tracking the progress of the SCIF.

Study approach

- 1.5 The study approach drew upon a mix of methods:
 - An extensive consultation programme with members of the SE Life Sciences team, the SE evaluation team, the Scottish Government, SCIF project managers, Scottish Stem Cell Network (SSCN) members and other stakeholders
 - Desk research on policy and industry context
 - Review of statistical sources and other secondary data
 - A regular programme of meetings with the SE steering group
 - A workshop with SSCN members and other stakeholders

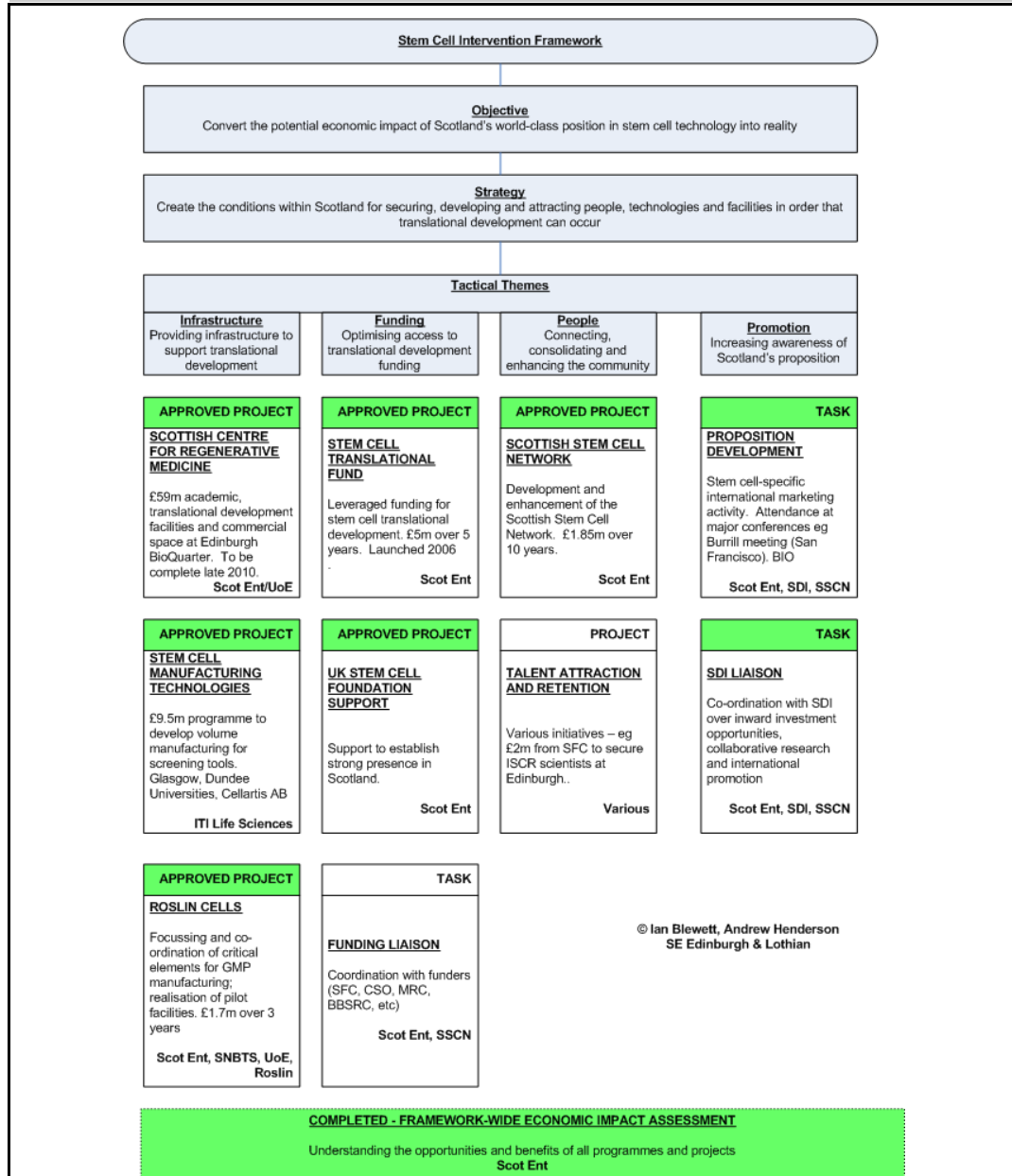
Issues to be addressed

- 1.6 In developing the monitoring and evaluation framework, the Study Team have had to work with four major issues.
- 1.7 **Uncertainty** – stem cell research is a very new activity and is attended by major uncertainties. Innovation is frequently non-linear in nature – the path to success tends to become obvious only with hindsight – but the stem cell area, drawing on the views of consultees and others, is possibly the one area of activity supported by SE where uncertainties are the greatest of all. These uncertainties attend all stages of development:
- **Research** – the particular source or sources of successful treatments are not yet determined. A variety of approaches are being pursued in Scotland and elsewhere.
 - **Proof of concept** – the demonstration that successful therapies can be developed from stem cells is currently lacking in most cases.
 - **Translational activity** – the process by which stem cell research can be taken through the development process to a marketable treatment is as yet untested. Associated with this are uncertainties over Intellectual Property Rights.
 - **Market** – the level of demand, the cost and the willingness to pay for these potential treatments are unknown.
 - **Investment** – reflecting the levels of uncertainty, private investment is largely absent from the sector at present.
- 1.8 **A focus on results** – stakeholders and consultees were united in the view that the monitoring and evaluation framework needs to focus on the reasons for SE involvement – the creation of an economically successful stem cell sector in Scotland – rather than simply measure what is available to be measured, or potentially skew activity towards meeting less relevant targets.
- 1.9 **Consistency with existing and future approaches** – SE is seeking to adopt a systematic approach to monitoring and evaluation across all of its interventions. This will provide better visibility of progress across all SE’s activities and should facilitate the thematic evaluation of projects in future. Guidance on the common approach was provided by the SE team and we have sought to take this into account.
- 1.10 **Size and type** – the stem cell sector is still very small. As such, it has little visibility in secondary sources or statistical analyses. There are additional problems of definition – just what constitutes stem cell research or a stem cell company? In addition, those active in the field, especially companies, may be reluctant to report on novel work in development.
- 1.11 We have sought to take account of all these issues in drawing up the monitoring and evaluation framework: we have sought to produce a framework that will help to give a common direction to the SCIF, will be straightforward in application, and will give meaningful assessments of progress in what is still a very uncertain environment.

2: Stem Cell Intervention Framework

- 2.1 In this section we describe the Stem Cell Intervention Framework and the national policy/strategic context in which it sits.
- 2.2 The SCIF has grown organically from 2003 onwards, when the first project in the Framework, the Scottish Stem Cell Network, was established. The SCIF fits within an increasingly well-defined policy context that is focusing Scottish Enterprise's efforts on those areas of the national economy that have the potential to deliver the greatest economic returns for Scotland.
- 2.3 The Framework consists of five SE funded projects, along with a number of internal tasks.

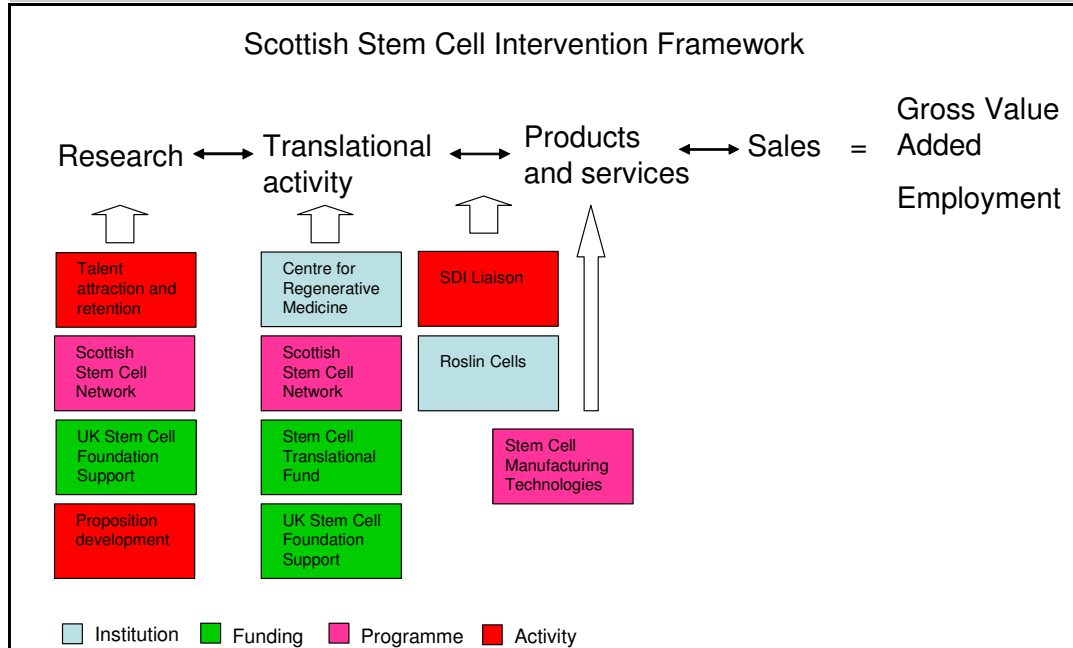
Figure 2-1 Stem Cell Intervention Framework



Source: Scottish Enterprise

- 2.4 The projects under the SCIF are focused on the earlier stages of the value chain, reflecting the level of maturity of stem cell research and application.

Figure 2-2 Simplified value chain and SCIF projects



Source: SQW

SCIF alignment with Government objectives

- 2.5 The Scottish Government has set five overarching strategic objectives for Scotland: to be wealthier and fairer; healthier; safer and stronger; smarter; and greener.
- 2.6 Should an internationally successful stem cell sector develop from the work of the partners, then the SCIF will contribute directly to the first objective, to “enable businesses and people to increase their wealth ...”.
- 2.7 Interestingly for an economic development intervention, many of the consultees emphasised the value of the SCIF to Scotland as a contributor to meeting the Government’s health objective. Scotland’s poor health record was seen as both challenge and opportunity, and therapies developed in Scotland, drawing on Scotland’s relatively well developed healthcare sector and comprehensive health records, could have direct national and local benefit. This is a theme we have seen developing in other parts of the UK where regional development agencies are looking to support regenerative medicine.
- 2.8 Beneath the overarching strategic objectives of Government sit five strategic priorities considered to be critical to achieving sustainable economic growth. These are: learning, skills and well-being; supportive business environment; infrastructure development and place; effective government; and equity.
- 2.9 The SCIF aligns with the supportive business environment priority which seeks to deliver responsive and focused business enterprise support to businesses and areas that have the potential to be highly successful. This priority also seeks to strengthen the links between Scotland’s research and business base, and to raise the levels of business innovation.

- 2.10 Importantly, the economic strategy states that there will be a particular policy focus on a number of key sectors with the potential for high growth. Government sets itself to work to build a critical mass of activity in:
- Creative Industries (including digital content and technologies);
 - Energy (with a particular focus on renewables);
 - Financial and Business Services;
 - Food and Drink (including agriculture & fisheries);
 - Life Sciences (including biotechnology and translational medicine);
- 2.11 The Scottish Government Spending Review (2007) sets out a national performance framework which the SCIF can ultimately deliver against.
- reduce the gap by half between Scottish and EU average GDP by 2011
 - increase the business start-up rate
 - grow exports at a faster average rate than GDP
 - improve knowledge transfer from research activity in universities
- 2.12 The work undertaken through the SCIF may also ultimately be able to address
- increasing healthy life expectancy
 - improve the quality of the healthcare experience

SCIF alignment with Scottish Enterprise objectives

- 2.13 Scottish Enterprise is charged with delivering the Government's economic development objectives. SE responded to the Government's economic strategy in its business plan for 2008-2011¹, committing, alongside private and public sector partners, to the target of raising Gross Domestic Product (GDP) to the UK level by 2011 (together with a number of other purpose targets).
- 2.14 The focus is to be on raising national productivity, with particular emphasis on identified performance shortfalls in enterprise, innovation and investment:
- Enterprise: provide responsive and focused enterprise support, helping growth companies and industries to reach their full potential
 - Innovation: stimulate innovation to support business growth including exploiting new products, processes and technologies
 - Investment: helping to create the right conditions for growth companies and industries to have access to property, markets and finance to help them grow.

¹ Scottish Enterprise (2008) *Business plan 2008-2011*

- 2.15 An important outcome from the Scottish Government's Enterprise Networks Review was a redefinition of the responsibilities of Scottish Enterprise and local authorities in relation to economic development. Scottish Enterprise has now been given a very clear remit to focus on priority sectors and on supporting those businesses, of whatever size, that have high growth potential and that are important to the national or regional economy. Local government will play a complementary in economic development, providing business advisory support to local firms. Scottish Enterprise is therefore required to help develop the potential higher growth/higher risk sectors in the Scottish economy.
- 2.16 Life Sciences, within which stem cell activity sits, is identified in the SE business plan as one of the priority sectors, and one where significant activity is already taking place (the example of the Translational Medicine Research Institute, which brings together the research strengths of Scotland's universities and health service, is cited as a success in attracting investment from the pharmaceutical company Wyeth). The SE business plan stresses the need to capitalise on the high-quality research being produced by Scotland's universities and research institutes as currently much of this supply is still not being used by companies to create economic growth.
- 2.17 The business plan is intended to be the start of a concerted effort to achieve a step-change improvement in the application of innovation in the marketplace. While the stem cell sector will not bear the whole burden of expectation, it is hoped that in the longer-term it will contribute to the growth of the Scottish economy.

Life Sciences strategy

- 2.18 The Life Sciences team within Scottish Enterprise revisited its strategy in 2008², intending to build upon the momentum in a sector considered to have significant opportunity for further expansion. The vision for the sector is:

A globally oriented, sustainable, fully connected life sciences sector built on collaborative action that exploits strengths in scientific excellence, financial services and innovative business models, and develops, retains and builds upon Scotland's talents. (Life Sciences Scotland, 2008)

- 2.19 The strategy focuses on the themes which a community consultation identified as critical to achieving growth:
- People – to attract the best and provide them with serial opportunities for employment
 - Technology - to invest in innovation and develop a streamlined process for commercialisation
 - Capital – to create an academic and business environment that sources of capital will seek to support

² Scottish Enterprise (2008) Life Sciences Scotland 2008

- Infrastructure – to provide facilities and communications to facilitate research and its exploitation
- Collaboration – to work together as Life Sciences Scotland to enable Scotland as a whole to compete more effectively globally

2.20 The strategy document notes that Scotland is not alone in further developing expertise in Life Sciences. Competition is global and will continue to challenge Scotland as it seeks to maintain a position in the top rank.

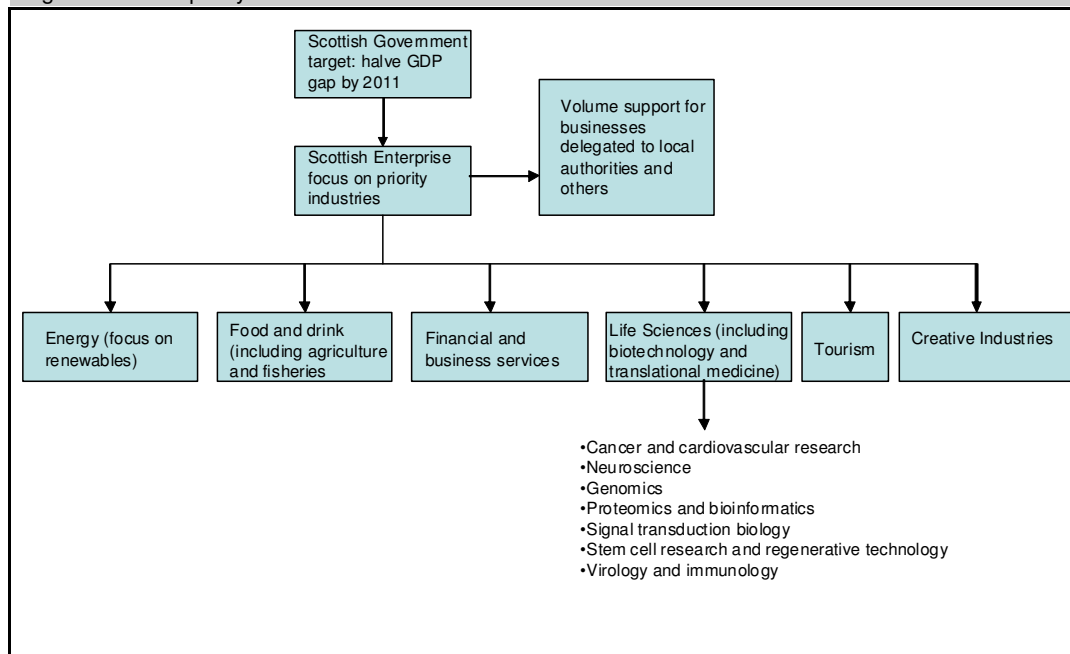
2.21 Scotland is considered to be well placed to address these challenges with research strengths in so many areas including stem cells, translational medicine, medical technologies and with capabilities in relevant contract research, along with the ability of industry to collaborate with the NHS and academic institutions.

2.22 The strategy notes that Scotland’s Life Sciences sector has traditionally focused on healthcare. However, there are significant opportunities for Scotland’s expertise and capabilities to be applied to industrial, marine, environmental and veterinary biotechnology.

Conclusions

2.23 There is a clear policy flow from the highest governmental level, which has set ambitious growth targets, through SE’s own business plan to achieve this high-level growth by concentrating resources on those areas considered to have the greatest potential, through the Life Sciences strategy which identifies the sector’s needs.

Figure 2-3 SCIF policy context



Source: SQW

2.24 The implications for this policy environment are that the weight of expectation will fall on those priority industries that have the potential to deliver the greatest growth. Both tourism and food & drink remain very significant sectors for Scotland in terms of employment,

however they operate in mature markets where growth at a sectoral level is slow. It will fall to the growth sectors of renewable energy, financial and business services, the creative industries and Life Sciences to deliver the required growth. These are also the sectors where the greatest risks and/or uncertainties lie. The implications of this are explored in the next chapter.

3: Managing in an uncertain environment

- 3.1 Scottish Enterprise has been set the challenge of working with public and private partners to develop those sectors where the greatest potential growth opportunities for Scotland have been identified. Economic growth in modern economies comes from change, as new technologies and processes supplant existing ones. With change comes uncertainty and risk. This is well recognised in investment – the first rule of finance is often held to be that risk follows return. If an investment offers the prospects of a particularly high return then one should expect a commensurate level of risk.
- 3.2 To achieve its objectives, Scottish Enterprise is obliged to focus on those areas where returns, and therefore risk, are greatest. In some respects, the situation is actually more difficult, as the *raison d'être* for SE is to intervene where there is market failure: where the market perceives there to be no immediate benefit or where the risks are considered to be currently too high. Companies can contain risks through a number of strategies, including probing and learning, collaborating and sharing with partners, and queuing up initiatives but waiting for uncertainty to clear before making large investments. Essentially SE has stepped in with the SCIF to take on the risk that the market is unwilling to take. For SE, as for private sector investors, the downside of risk is two-fold: loss of reputation and loss of resources.

Managing risk

- 3.3 There is an ongoing debate as to how the terms “uncertainty” and “risk” should be used. Here, we have preferred the work of Hubbard³ where:

Uncertainty – is the lack of complete certainty, more than one future possibility exists

Risk – a state in which where one or more of the possibilities involves a material loss or other undesirable outcome.

- 3.4 The stem cell area is currently characterised by uncertainty – researchers are simply not yet in a position to say what successful treatments may be derived from their research or from which particular line of enquiry these results will come. There is uncertainty for example over how potential treatments will fare in progressing through the different stages of clinical development. Uncertainty is further increased by the characteristics of the end-market – will these treatments receive regulatory approval, will they be affordable to health services?
- 3.5 By entering the stem cell area through the investment of public resources in the form of skilled personnel and funding SE has taken on a risk – as has been demanded of the organisation. The question now is how SE in seeking to help realise the potential of Scotland’s stem cell research can best manage its exposure to the potential downside of the sector either failing to deliver on its promise generally, or, if stem cell research is successful globally, of the Scottish stem cell sector in particular not realising its full commercial potential.

³ Douglas Hubbard (2007) *How to Measure Anything: Finding the Value of Intangibles in Business*

3.6 The standard approach to investment risk is what is termed portfolio theory. Where there is uncertainty about which investments will provide the best returns, the risk can be spread by placing money in a range of investments. In essence, this is what the Scottish Government and Scottish Enterprise have done through their priority industries strategy – investment is spread across a range of sectors with Life Sciences lying at the higher end of risk/return. In turn the Life Sciences strategy covers a range of activities within the sector, with stem cell activity again lying at the high end of risk/return. What, therefore, can the Life Sciences team do to manage its investment? A range of methods are used in managing the innovation pipeline, as illustrated in Table 3-1.

Table 3-1 Managing risks in innovation investment

Method	Comment
Contain risks	Delay large and irreversible commitments for as long as possible, share gains and losses with partners wherever possible, and get early warnings of problems so that action can be taken.
Obtain market signals	In situations of uncertainty, there is a need to obtain as many internal and external checks as possible, from potential investors, potential customers and from others working in these areas.
Treat innovation as a system	Investment is not simply a go/no go gate – projects will require ongoing attention to ensure they do not run out of resources, encounter bottlenecks or come into conflict
Justification at each stage	Consistent steps where financial, operational and market hurdles can be reviewed and the decision to proceed taken.
Leverage external partnerships	Seek collaborations where these can lend speed, economy or a ready source of relevant expertise.
Evaluate both the portfolio and the pipeline	There needs to be visibility both across the whole field of activity, and within the innovation pipeline for each project.
Use appropriate measures	The more radical an innovation the less a short-term measure of success is likely to be appropriate. Instead, intermediate impacts showing progress is being made can be employed.
Kill unsuccessful lines of activity	The success of the portfolio approach is to exit when the innovation has failed – this can be difficult due to reputational concerns and organisational inertia.
Support promising lines of activity	Conversely, the portfolio approach can also underperform when reputation and inertia mean support is not diverted to those areas showing promise.

Source: SQW, drawing on the work of Christian Terwiesch and Boston Consulting Group

3.7 At this stage in the development of the stem cell sector in Scotland, SE requires:

- maximum visibility of activity in Scotland, especially that receiving public support
- early warning of projects being unable to deliver objectives or of the original objectives becoming obsolescent
- identification of any gaps or bottlenecks in the translation of research into products and services

- a means of identifying emerging opportunities
 - as far as possible, market signals from potential investors, collaborators and customers.
- 3.8 SE is operating here at one remove, it can only provide support to those institutions active in Scotland and to the activities they are pursuing. However, in making its investments, SE needs to be aware of what is happening elsewhere within stem cell research and relevant markets and to track how Scotland’s current pattern of activity maps onto these.

Line of sight to market

- 3.9 The identification and sizing of markets is an area of strategy development that has exercised business strategists for decades. Issues to be taken into account include potential customers, competitors, potential entrants, and substitutes.
- 3.10 Sizing established markets can be difficult enough, where there are existing data to draw on - it is even more difficult to estimate market size and profitability in areas where the market is still developing. The difficulties can be illustrated by the experience of two products⁴:
- 3.11 **Innovation A:** a quick start, with first-year sales of more than \$200 million. The innovation had a clear value proposition, good positioning, and a strong distribution network in place.
- 3.12 **Innovation B:** achieved first-year revenues of only \$220,000. The innovation had proprietary technology, but the customer and the business model were very unclear.
- 3.13 Innovation A was Vanilla Coke. Despite knowing the market area very well, Coke’s new product largely cannibalized the sales of other Coke products. Three years after launch, failing demand led Coke to pull the product from the market. Innovation B was Google. In its early days the company’s main asset was its technology and it struggled to define a workable business model. It took a number of iterations before the company came up with its advertising-based model, and the foundation for success.
- 3.14 The stem cell market is still in its infancy, and researchers and companies have little to no data on which to base assessments of the potential size and profitability of the market, or the types of business model that might succeed.

Table 3-2 Developing a line of sight to market

Stage	Issues
Idea that market exists or could exist	The basic identification of the target market – either existing or that could potentially be created.
Proof of concept	Establishing that a technology or approach is possible.
Business model	Developing a business model that matches the offering against the target markets, and takes into account likely costs, number and type of customers and their ability to pay.
Launch and early feedback	Launch of product into marketplace, potentially on a limited or trial basis, with the opportunity to incorporate

⁴ “How Can \$220,000 Trump \$200 Million?”, Scott Anthony, Harvard Business Publishing

Stage	Issues
	feedback into market assessments.
Growth	Ramping up of production and delivery with increasing flow of data.
Same product/service into new markets	Launching an established product or service into a new market, drawing on the existing product/service data.

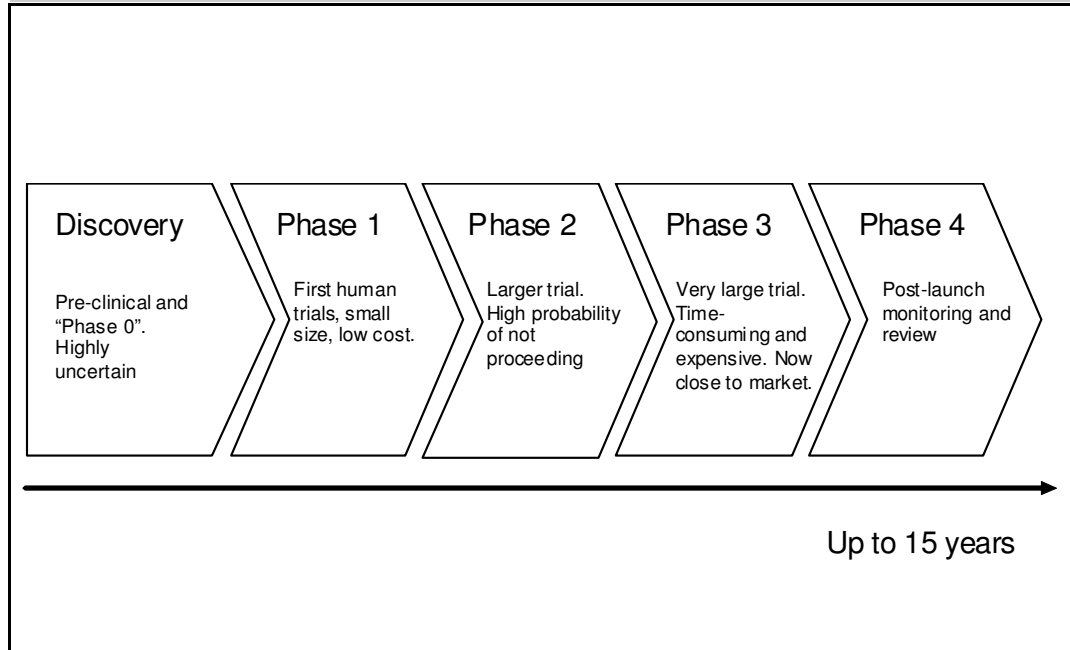
Source: SQW

- 3.15 The stem cell sector as a whole is at the first four stages of market scoping, with only a handful of products and services actually launched, and a much larger body of activity at the proof of concept stage or earlier.
- 3.16 As more commercial activity takes place, in Scotland and elsewhere, then greater market intelligence will begin to be generated.

Intermediate outcomes

- 3.17 With the stem cell sector still a significant way away from delivering on its potential, and with the ultimate market for its products as yet uncertain, SE and its partners will need to largely depend on measuring progress towards the ultimate objective of a successful stem cell sector against a set of intermediate outcomes or impacts that indicate movement in the right direction.
- 3.18 These intermediate outcomes do not guarantee final success – the nature of the field and of the market means that even promising developments can fail at a number of stages in the transition from research to approved therapy. Assuming stem cell research follows the pattern set by more conventional therapies, then it could take up to 15 years for a therapy to make it from “bench to bedside”(see Figure 3-1). As a rule of thumb, it can take up to six years in conventional therapies to identify and test promising candidates, and up to a further eight years for a therapy to make its way through clinical trials.
- 3.19 In the interim, SE and its partners will need to look for evidence that the initial flow of discoveries is sufficiently large and these are entering and proceeding through the different clinical gates.

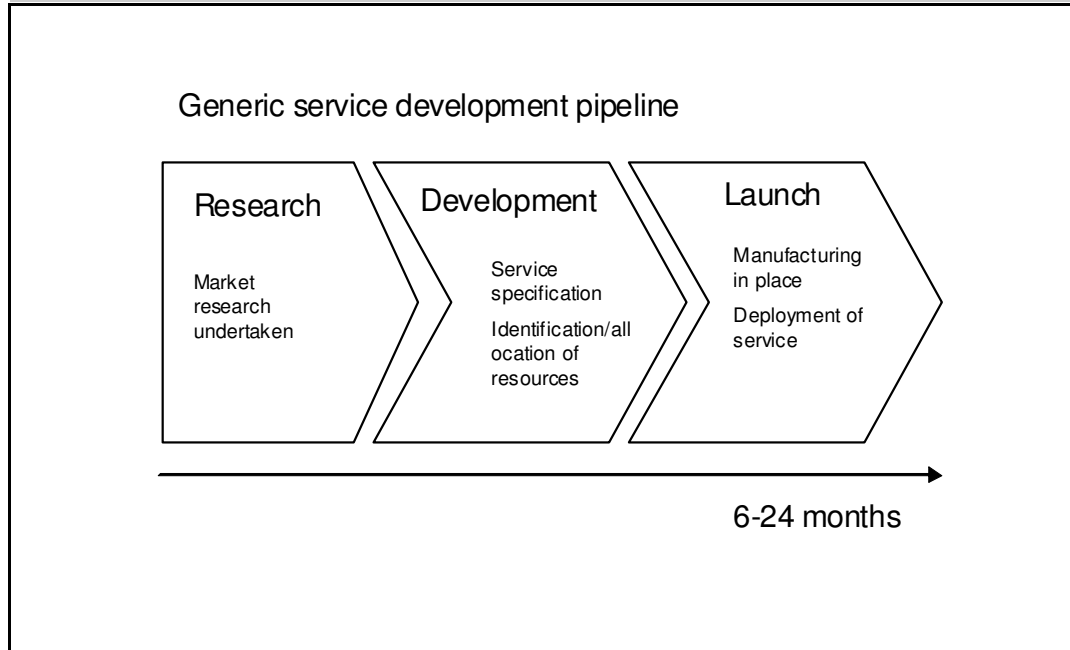
Figure 3 -1 Generic therapeutic pipeline model



Source: SQW

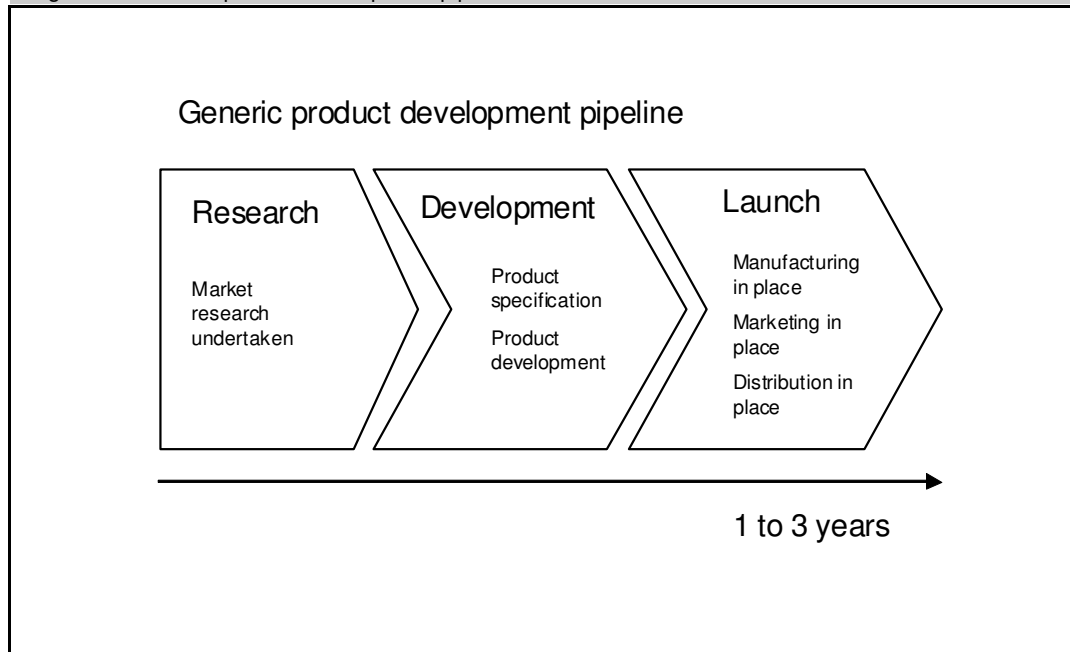
- 3.20 In addition to the development of therapies, there are emerging areas of products (medical devices) and services that can be regarded as spin-offs from the main thrust of stem cell research. These include the use of tissue for toxicology testing (speeding up the development of mainstream treatments), reagents, cord blood banks, and veterinary treatments (where the hurdles to approval are lower).
- 3.21 These developments are not subject to the same level of regulatory oversight as therapies and can therefore be developed more quickly (see Figures 3-2 and 3-3). Products and services also differ from therapies in that they are not the subject of a discovery process, but typically based on market research. The pipeline for both is therefore considerably shorter and it will be appropriate to review progress to market much sooner.

Figure 3-2 Generic service development pipeline model



Source: SQW

Figure 3-3 Generic product development pipeline



Source: SQW

3.22 Table 3-3 sets out a number of intermediate outputs and impacts that, based on discussions with consultees, are necessary (though not sufficient) for the Scottish stem cell sector ultimately to succeed. Should the SCIF projects deliver against these, then SE and partners can have confidence that the groundwork is at least being laid for the future success of the sector.

Table 3-3 Intermediate outputs and impacts for SCIF

Intermediate outputs and impacts	Description
Creation and use of Intellectual Property	Relevant patents taken out by Scottish-based companies and institutions. Use made of patents by others indicating their value to the sector.
Licensing of research	Research being licensed to third-parties (in or out of Scotland).
Creation and use of stem cell lines	Number of registered stem cell lines created. Sale/use of stem cell lines by third parties (in or out of Scotland).
Collaborations entered into with others	Number of formal collaboration arrangements between Scottish institutions and companies.
Investment by third parties	Investment in specific projects from public sources, such as proof of concept projects and from the SE Co-investment Fund (number and size of investments). Investment in specific projects by private sector companies or individuals (number and size of investment).
Number of discoveries entering pre-clinical phase	Number of relevant research discoveries under review in Scottish institutions.
Therapies in Phase 1	Number of therapies entering Phase 1 clinical trials.
Therapies in Phase 2	Number of therapies entering Phase 2 clinical trials.
New medical device products	Number of products at development stage Number of relevant medical device products launched relating to stem cell treatments developed in Scotland.
New services developed	Number of services at development stage Number of new services launched based on stem cell research – e.g. toxicology testing.
Spin-out companies	Number of companies launched in Scotland to capitalise on stem cell research.

Source: SQW

- 3.23 There is a question as to how much of this activity should take place in Scotland. In an ideal world it would be good for the Scottish sector to see these collaborations developing within Scotland, but in reality it will be more important for a Scottish involvement in these to take place at all. Scotland is a small, open economy (and one with a limited market for healthcare) and its success will depend on making global connections in IP creation, in collaborations, in investment, in clinical trials and finally in sales.

Business environment mapping

- 3.24 SE can only help create the conditions for success, it will not undertake the research or clinical trials, nor package and market the therapies. What SE can do, along with its public and private partners, is help create the environmental conditions in which private efforts can flourish.

3.25 SE is working on a systematic approach to identifying strengths and weaknesses in the business environment, for Scotland as a whole and for specific sectors. The business environment mapping approach identifies six spheres of activity and ways in which they can be measured:

- **People (Human Capital)** - Mapping recruitment challenges and skills requirements; the number and type of graduates, and high value jobs recruitment
- **Things (Physical Capital)** - Mapping physical assets including incubator centres, test rigs, support labs etc.
- **Know-how (Intellectual Capital)** – Measuring innovation and R&D performance in Scotland compared with other EU and OECD competitors; reviewing the IP landscape for Scotland; levels of research funding and numbers of people in academic institutes
- **Money (Financial Capital)** – Reviewing the current picture of equity investment, including levels of investment and active investors. Determining the indicative time and costs to commercialisation. Identifying later stage company growth issues as they arise
- **Global positioning (Market Capital)** – Drawing on success/failure information on Foreign Direct Investment from Scottish Development International; review of exporting levels
- **Growth of Networks (Social Capital)** – The study of industry bodies and inter-organisation joint working; use of Social Network Analysis to trace the type and extent of contacts.

3.26 A significant part of the SCIF is directed towards creating a supportive business environment for this nascent sector. It will therefore be appropriate to draw on these categories of impact, as far as possible.

3.27 Based on consultations with the Life Sciences team, project managers and other stakeholders, a qualitative assessment of the current stem cell business environment in Scotland would be as shown in Table 3-4.

Table 3-4 Headline business environment mapping for the Scottish stem cell sector

Asset	Classification (strong, medium, weak) and comments
Human capital	Strong. The basis for SE's support in this sector. Research expertise is considered to be world class.
Physical capital	Medium. Significant investments in infrastructure but uncertainty over just what will be required in future makes this difficult to assess.
Intellectual capital	Medium. Measured in terms of competitive funding, Scotland is in the second tier of UK regions. The sector is currently too small to be captured in general R&D or innovation surveys. IP position is currently unclear.
Financial capital	Weak. The sector is currently attracting very little private investment due to uncertainties over business models

Asset	Classification (strong, medium, weak) and comments
	and pathways to market. This potentially will change as pharma companies become more interested in aspects of stem cell research.
Market capital	Medium. Scotland has attracted some overseas investment in this area. Exporting levels are low or non-existent due to the stage of development of the sector.
Social capital	Strong. The Scottish Stem Cell Network is considered one of the leading networks of its type, it has good coverage of the Scottish research and business base, and other networks seek it out.

Source: SQW

- 3.28 Given the stage of development of the sector, its small size and the preferred focus on quality rather than scale of inputs and activities, it would not be appropriate to measure progress against all the measures suggested for mainstream business environment mapping in Section 3.25. Instead, a smaller number of selected indicators of progress appropriate to the sector should be drawn upon.

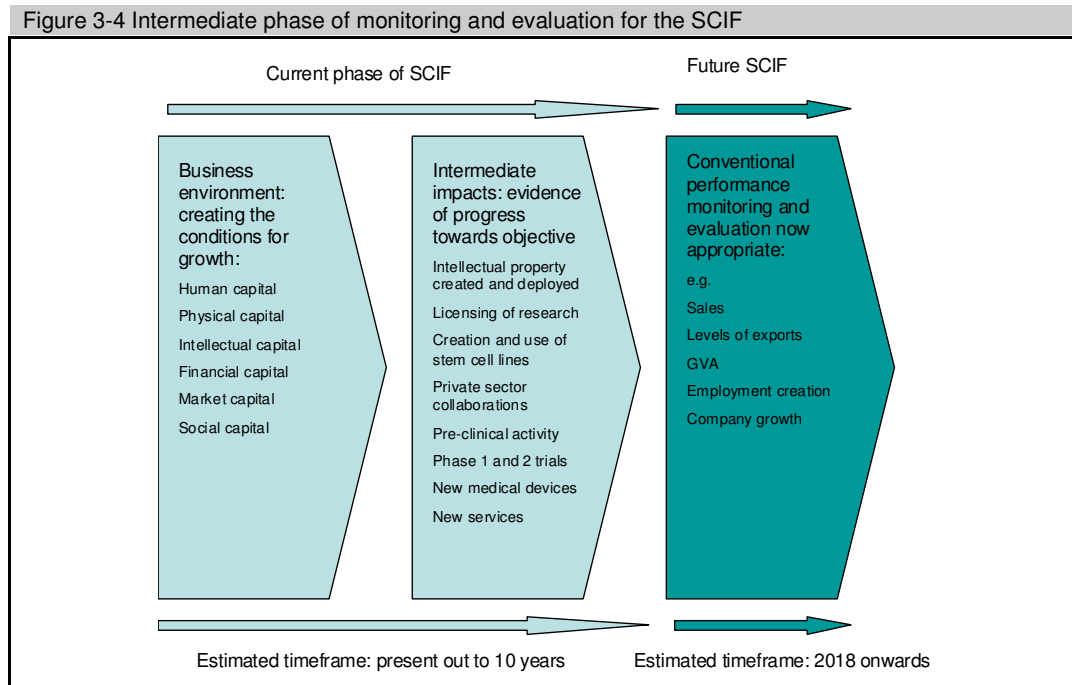
Table 3-5 Measuring the effect on the business environment - suggested measures for the Scottish stem cell sector

Asset	Measurement of progress
Human capital	Maintain high level of human capital as measured by existing standards, such as the Research Assessment Exercise. Retain and attract high-quality human capital.
Physical capital	Progress on completion and occupancy levels in those projects with a physical infrastructure component.
Intellectual capital	Levels of competitive funding won by Scottish institutions for stem cell research as compared to peer regions.
Financial capital	Numbers of potential investors visiting and interacting with the sector. In the longer term, levels of private investment entering the sector.
Market capital	Levels of FDI into the sector. New collaborations with overseas partners. Longer-term, the levels of exports.
Social capital	Level of useful activity within network. Satisfaction ratings by network members. Number and intensity of contacts with other networks.

Conclusions

- 3.29 We therefore propose two sets of indicators for the SCIF projects:
- Intermediate outcomes/impacts - these measure the intermediate impact of specific project activities taken as evidence that progress is being made towards commercialisation

- Business environment contributions – these measure the extent to which the Scottish stem cell sector remains or is becoming a more desirable location in which to carry out stem cell work.

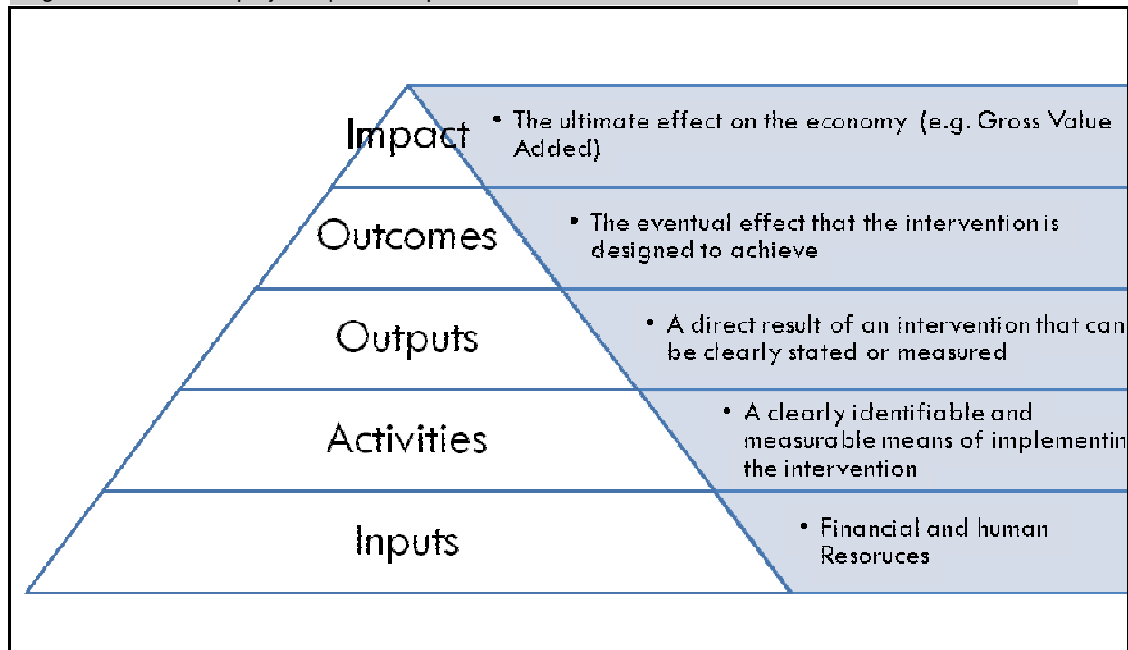


- 3.30 Projects under the SCIF will have a mix of these, depending on the particular objectives of the project.
- 3.31 Should the SCIF projects give rise to commercial medical device and services (as shown in Figure 3-2 and 3-3), then economic impacts are likely to flow sooner, and more conventional measures of company creation/growth, employment and GVA would be appropriate. However, the bulk of the SCIF intervention is focused on the “blockbuster” potential of stem cells as medical treatments. In the views of consultees, a much longer timeframe is attached to these, hence the need for the intermediate outputs and impacts to assure partners that progress is being made, and to refine expectations about timeframes as more data becomes available.

4: Monitoring and evaluation of SCIF projects

- 4.1 Good monitoring and evaluation practice is required of all projects supported by Scottish Enterprise. The expectation is that this will drive both good project performance (and allow any issues affecting progress to be identified and addressed) and allow the ultimate impact of the project to be assessed.
- 4.2 The monitoring and evaluation frameworks for the projects are expected to follow the logic chain in Figure 4.1, as set out by Scottish Enterprise.

Figure 4-1 Flow from project inputs to impact



Source: Scottish Enterprise

- 4.3 As discussed in Chapter 3, we do not currently consider it possible to apply mainstream measures of progress at the project level, especially in relation to impact on GVA. We therefore propose a revised set of indicators to be used in the interim:
- Rationale – the specific rationale for the intervention against which the relevance of activities can be assessed and achievement measured
 - Inputs – financial and human resources
 - Activities – clearly identifiable and measurable means of implementing the intervention
 - Outputs – direct results of the intervention that can be clearly stated or measured
 - Intermediate outcomes – the change from the *status quo ante* that the intervention has achieved

- Intermediate impacts – the specific impacts that the intervention has achieved, and which are taken to represent milestones towards the final achievement of impact.

Project level

There are currently five projects operating under the SCIF:

- the Scottish Centre for Regenerative Medicine
- Stem Cell Manufacturing Technologies
- Roslin Cells
- Stem Cell Translational Fund
- Scottish Stem Cell Network

Scottish Centre for Regenerative Medicine

4.4 Scottish Centre for Regenerative Medicine is made up of the Institute for Stem Cell Research (ISCR), a world-leading centre for multidisciplinary research in mammalian stem cell biology, and clinical research groups within the College of Medicine and Veterinary Medicine of the University of Edinburgh. The Centre regards its mission as:

- to gain fundamental understanding of the biology of stem cells
- to use this knowledge to improve human health
- to provide leadership in training the next generation of basic and clinical scientists in stem cell biology and regenerative medicine
- to act as a centre for public engagement, information and debate, and as a resource and source of advice for policy makers.

Table 4-1: Scottish Centre for Regenerative Medicine – proposed monitoring and evaluation framework

Rationale	Inputs	Activities	Intended outputs	Intermediate outcomes	Intermediate impacts
Market failure – Imperfect information Translation of research into commercial opportunities is vital to success, however a funding gap at this stage exists as significant resources are needed but venture capitalists will not invest because of the high risks, pharma companies remain cautious and universities have little incentive to undertake trials.	£59 million (£24 Scottish Government, £19 million University of Edinburgh, and £16 million Scottish Enterprise)	Consolidation and expansion of Edinburgh University's existing research groups. Creation of a centre for 'scale-up' development and manufacturing of cells to a GMP standard. Space to accommodate commercial stem cell research organisations and spin-outs.	Facilities for 150 researchers. 150 researchers recruited. 900 metres of space for scale-up/GMP manufacturing. 675 square metres of premises for commercial firms.	Retention/attraction of leading researchers. Improved collaboration between research and company base. Increased investment attracted. New products and services developed from Scottish research.	Investment by private sector. Number of discoveries entering pre-clinical phase. 100% occupancy of premises by private companies by 2011. 5 lines of research licensed by. 3 spinout companies created by 2011. Number of products at development stage Number of new products launched Number of services at development stage Number of new services launched

Source: SQW(drawing on Biggar Economics Scottish Centre for Regenerative Medicine Economic Impact Assessment)

- 4.5 Based on a review of SCRM activity, we would therefore suggest the measures outlined in Table 4-1.
- 4.6 The SCRM benefitted from an Economic Impact Assessment⁵ in 2006. However, as described in more detail in Annex E, we consider the targets proposed to be ambitious. We have therefore drawn on the Biggar estimates for progress up until 2011 (the estimates extend until 2015) and would suggest reviewing these should progress fall short of these projections.

Stem Cell Manufacturing Technologies

- 4.7 In January 2007, ITI Life Sciences initiated an R&D programme to develop novel technologies and automated processes to produce high-quality human stem cells as tools for pharmaceutical research.
- 4.8 ITI Life Sciences has committed £9.5 million to the three-year programme, which will be conducted by an industry-academia collaboration initially comprising:

- Cellartis

⁵ Biggar Economics (2006) *Scottish Centre for Regenerative Medicine: Economic Impact Assessment*

- University of Glasgow (Faculty of Medicine and Faculty of Biomedical and Life Sciences)
- University of Dundee
- Heriot-Watt University.

4.9 As part of the programme, Cellartis is setting up an R&D and manufacturing facility in Dundee, which is expected to create up to 75 high-value jobs, and is supported by a £1.2 million Regional Selective Assistance grant from the Scottish Government.

4.10 This project aims to develop stem cell specific tools and is looking to scale up the use of stem cells. It is hoped that it will act as a catalyst to increase collaboration both in Scotland and internationally. It is argued that internal relationships within Scotland will stimulate and strengthen a cluster effect.

Table 4-2: Stem Cell Manufacturing Technologies – proposed monitoring and evaluation framework

Rationale	Inputs	Activities	Intended outputs	Intermediate outcomes	Intermediate impacts
Market failure – Imperfect information. Currently discourages private investment although manufacturing of cells will be essential to commercialising research. SCMT is intended to develop the capabilities to manufacture stem cells in advance of need.	£9.5 million (Scottish Enterprise) £1.2 million (Scottish Government through Regional Selective Assistance)	Establishment of R&D facility. Establishment of manufacturing facility.	Cellartis – Volume and quality of cells (not yet specified). Dundee University – Number of cells (not yet specified). Heriot Watt – success in the modification of cells. Filing of patents.	Improved research-company base relations. Development of stem cell-specific manufacturing technologies. Scotland possessed of the ability to scale-up and manufacture stem cells.	Production of stem cell lines. Uptake of stem cell lines.

Source: SQW

4.11 Based on a review of SCMT activity, we would therefore suggest the measures outlined in Table 4-2 as a minimum for recording progress.

Roslin Cells

4.12 Roslin Cells Ltd is a not-for-profit company, established by the Roslin Institute to consolidate and develop its expertise in human stem cell research. The Company will focus on developing new cell lines for research and clinical use.

Table 4-3: Roslin Cells Centre – proposed monitoring and evaluation framework

Rationale	Inputs	Activities	Intended outputs	Intermediate outcomes	Intermediate impacts
Market failure – Imperfect information	£1.7 million (Scottish Enterprise)	Upgrade of laboratory space	Facilities for 150 researchers	Retention/attraction of leading researchers	Creation of useable stem cell lines based on human embryonic stem cells
Translation of research into commercial opportunities although essential is weak as public sources of funding for research offer only limited support for translational activity and private sources are lacking in Scotland.	Hosting of Roslin Cells for 3 years (Roslin Institute) Management of infrastructure; funded development projects to run within Roslin Cells (University of Edinburgh)	Purchase of equipment		Availability of human embryo-derived stem cells for Scottish companies Enhancing the Roslin brand	

Source: SQW

- 4.13 Based on our understanding of current Roslin Cells activity, we would therefore suggest the measures outlined in Table 4-3 as a minimum for recording progress.

Stem Cell Translational Fund

- 4.14 The Stem Cell Translational Fund is intended to move research projects into clinics and to secure Scotland as a leading centre for stem cell translational activities. The focus is on public sector (NHS and academic) projects. There is also an R&D fund that can finance private sector projects.

Table 4-4: Stem Cell Translational Fund – proposed monitoring and evaluation framework

Rationale	Inputs	Activities	Intended outputs	Intermediate outcomes	Intermediate impacts
Market failure – Imperfect information	£5 million	Grant funding of translational stem cell activity	Number of lines of research undertaken.	Attract international companies to collaborate with Scottish researchers resulting in inward investment and possible co-location	Creation of IP Progress of 2-3 Scottish based regenerative therapies into Phase 1 clinical trials by 2011.
Regenerative medicine continues to require large-scale public investment in collaborative research.					Progress of 4-6 Scottish based regenerative therapies into Phase 1 clinical trials by 2014
However, in the shorter term, an opportunity exists to generate drug discovery tools based on stem cell technologies, and to capture value from				Scotland gaining a reputation as a primary global location for stem cell clinical trials resulting in more clinical trials being conducted here	New medical device products produced

Rationale	Inputs	Activities	Intended outputs	Intermediate outcomes	Intermediate impacts
developing GMP manufacturing facilities and know-how					

Source: SQW

- 4.16 Based on our understanding of the purpose of the Stem Cell Translational Fund, we would therefore suggest the measures outlined in Table 4-4 for recording progress.

Scottish Stem Cell Network

- 4.17 The Scottish Stem Cell Network (SSCN) brings together scientists, clinicians, businesses and society to enable advances in stem cell biology to be rapidly translated to deliver new treatments for degenerative diseases. Launched in 2003 initially as a pilot project with support from Scottish Enterprise Edinburgh and Lothian, it is now moving towards being a self-supporting membership organisation based in Edinburgh.

Table 4-5: Scottish Stem Cell Network - Proposed monitoring and evaluation framework

Rationale	Inputs	Activities	Intended outputs	Intermediate outcomes	Intermediate impacts
Market failure – Imperfect information	£1.75 million (Scottish Enterprise)	Delivery of workshops.	345 annual attendees to day events each year.	SSCN to become self-supporting over period.	Satisfaction ratings by network members.
The SSCN seeks to correct the information deficiency associated with an emergent field through consolidation, protection, enhancement and promotion of stem cell science and technology development in Scotland.	£1.75 million (private sector contributions) (over ten years)	Hosting an annual international conference. Attending overseas events per year. Attending non-SSCN national events per year. SSCN delivering 1 public outreach activity per year. Hosting/assisting with inward investment visits Information dissemination (website and newsletters) Networking activity with UK, European and international networks SSCN selling membership to all major players in the Scottish stem cell sector within 10 years	500 attendees to biennial international conference.	Increased interactions within Scottish stem cell community and with organisations and networks outside.	Number and intensity of contacts with other networks. Numbers of potential investors visiting and interacting with the sector. Number of collaborations established Number of researchers attracted

Source: SQW

- 4.18 The SSCN has a wider role than the other projects in the framework. Based on its outlined activity, we would therefore suggest the measures outlined in Table 4-5 for recording progress.
- 4.19 The SSCN also has a number of metrics against it derived from an earlier economic impact assessment. These are reviewed in more detail in Annex E.

Measuring progress at Framework level

- 4.20 The SCIF ideally should be more than the sum of its parts, and there can be expected to be achievements at a sectoral level that cannot be directly attributed to individual projects. It will therefore be appropriate to measure the general “health” of the sector at Framework level, drawing on the business mapping indicators.

Table 4-6: Scottish Stem Cell Intervention Framework - Proposed monitoring and evaluation framework

Rationale	Inputs	Activities	Intended outputs	Intermediate outcomes	Intermediate impacts
Co-ordinating role ensuring that projects under SCIF work together to best effect	SE staff input Contributions by other stakeholders	Co-ordination of SCIF projects and activities	Better linkages between projects Increased social capital: inter-organisational networks and cooperation that benefits the sector	Supporting the move from high quality research towards commercial activity	Retain and attract high-quality human capital Levels of competitive funding won by Scottish institutions in relation to stem cell research Levels of private investment entering the sector Levels of FDI into the sector Collaborations with overseas partners Levels of exports

Source: SQW

- 4.21 As the sector’s information clearing house, we recommend that the SSCN consider taking on the lead role in business environment mapping for the stem cell sector in Scotland. This activity will feed in to its ability to represent the issues concerning the sector to other stakeholders.

5: National and international comparators – principles

Purpose of national and international comparators

- 5.1 From discussions with the steering group and stakeholders, two key research questions have been identified which the national/international comparators element of the study is intended to address:
- to assess Scotland's progress towards becoming a world class self-sustaining centre for stem cell work
 - to identify areas in the stem cells industry which are profitable and where Scotland is weak so it can be assessed whether resources can/should be allocated to these areas.

Constraints

This study is expected to be repeated in future, with the data gathered here forming a baseline against which to measure progress. The resources available for future monitoring and evaluation are not yet known, but as a guideline we have taken the following estimates:

- total evaluation completed within 2 weeks
- international comparison completed within 4 days.

Approach

- 5.2 The approach has therefore been to identify measures of activity that have the greatest explanatory power, which are readily available and which can be applied across a range of regions or countries. This has led to three levels of analysis.
- 5.3 **Research** – Research activity be assessed by drawing on data showing success in winning competitive funding. Winning research grants shows that peers in the relevant academic community believe that the work is of a high standard, likely to produce excellent results, and is likely to generate more research outputs thus increasing the potential for commercial opportunities to arise. At a UK level, these data have been collected from the Medical Research Council, the Biotechnology and Biological Sciences Research Council and the Wellcome Trust. At a European level, the results from the 6th Framework Programme have been drawn on (which also provides some indication of collaborative activity). In addition, competitive research funding has been used to assess the relative regional strengths in the US, the largest centre of stem cell research activity.
- 5.4 **Translational activity** – Translational activity is the hardest area to research and measure. In the UK, we have drawn on data on clinical trials and on the developing area of funding awards for translational activity. Reliable EU-level data on clinical trials are not currently available, although this seems likely to change, possibly in time for the next review of the

stem cell sector. In the US, we have been able to draw on comprehensive records of clinical trials which show scale and intensity.

- 5.5 **Company base** – We have assessed the company base in terms of the number of identifiable stem cell companies, and the number of products and services. Where possible, we have identified the stage of development (in research, in clinical trial, launched). We have also sought to identify data on employment and investment in these companies, although these types of data are only partially available – where these can be sourced, they give a useful indication of scale.

6: National and international comparators – key findings

Headline findings

- 6.1 The key findings from the national/international comparators review were:
- the strengths evident in many of the English regions in research and translational activity – this had not been evident from the stakeholder consultations
 - the extent of stem cell activity across Europe, rather than only in those regions that enjoy a high media profile in relation to stem cells. The level of activity in the “southern” countries of France, Spain, Italy and Germany was particularly striking.
 - the strong state of development in the European company base, as measured by willingness of companies to commit resources to participate in the 6th Framework Programme
 - the state of development of the US company base as measured by products in development or launched
 - cord stem cell, bone support and dental companies starting to move products into the market
 - growing interest in spin-offs from stem cell research, such as in toxicology testing, and private investment is starting to flow into these.
- 6.2 In terms of where Scotland sits on these measures at the present time:
- Research – strong, among the leading UK regions
 - Translational activity – a mixed picture, with some success in winning translational funding, but weaker in clinical trials activity compared to other UK regions. Internationally, clinical trial activity appears more extensive.
 - Company base – respectable in product/services when compared to other EU and American regions given relative size.
- Overall, it is not currently possible to rank Scotland’s stem cell sector in relation to other regions around the world – whether on a straight comparison or on a weighted basis. The sector is still developing and its core promise of a transformation in medicine has still to be realised.
- 6.3 In the remainder of this chapter, we give headline data on the Scottish stem cell sectors relative position. Further detail is available in Annexes B, C and D.

Research performance

Research performance – UK level

- 6.4 We used Medical Research Council and the Biotechnology and Bioscience Research Council research awards to map UK-level stem cell research activity.

Table 6-1 UK-level stem cell research activity, MRC/BBSRC competitive research awards (October 2004-March 2008)

	MRC/BBSRC awards
London	12
Scotland	6
East Midlands	6
East of England	5
West Midlands	3
South East	3
North West	2
South West	1
Wales	1
Yorkshire	1

Source: Medical Research Council/ Biotechnology and Biological Sciences Research Council

- 6.5 Based on these data, London is the leading region in winning competitive research, with Scotland, the East Midlands, and the East of England forming a second tier. The West Midlands, the South East, and North West have lower levels of activity, while the South West, Wales and Yorkshire have only one award to date.

Research performance – European level

- 6.6 Research activity at EU level has been captured through the results of the 6th Framework Programme. There are known issues about UK participation in the Framework Programmes generally, but this source does allow a comparison to be made right across the European Union in a way that levels out national differences in research or funding regimes. It also takes in non-EU countries, such as Israel, Norway and Switzerland which have well-developed research bases.

Table 6-2 Involvement in stem cell research under the 6th Framework Programme

Country	Number of projects involved in	% share of funding
Germany	83	20.1
England	71	12.5
France	65	10.9
Italy	61	10.0
Switzerland	48	5.8
Spain	46	4.9
Netherlands	43	5.7

Country	Number of projects involved in	% share of funding
Sweden	43	6.6
Belgium	38	4.6
Austria	29	2.8
Israel	26	2.7
Denmark	23	1.9
Finland	17	2.2
Scotland	16	1.7

Source: European Commission/SQW analysis

- 6.7 Germany, France, and Italy are all strong performers under this measure – despite the received wisdom that they are less active in this research area. Scotland has a comparable level of involvement to Finland, but it is lower than other similarly sized countries such as Israel, Denmark, Sweden and Belgium.
- 6.8 In terms of funding won, Scotland shows a similar ranking to awards won (although Finland moves up and Denmark comes down). Again, we see a strong performance from countries not previously identified as strong performers in stem cell research.

Research performance - international

- 6.9 There is no common source for competitive research funding internationally to draw upon. The international level of analysis is therefore approached differently.
- 6.10 In the US, the single largest area of stem cell activity, the National Institute of Health's awards were used to identify the strongest regions in research terms – Massachusetts, and Northern and Southern California. Other regions were identified through discussions with consultees (see Annex D, from D10 onwards).

Translational activity

Translational activity - UK level

- 6.11 In assessing translational activity, we drew on three sources: awards for translational work made by the Wellcome Trust, awards made by the UK Stem Cell Foundation, and data on clinical trials.
- 6.12 The Wellcome Trust has set up a fund to support translational stem cell activity (the Medical Research Council is currently in the process of establishing a similar fund). Awards under these funds are considered to be indicative of the ability to generate convincing proposals for translational activity, although to date only a limited base of data exists.

Table 6-3 Wellcome Trust translational awards to date

Title	Institution	Location	Comment
Tissue engineering of teeth	Odontis Ltd	London	Spin-out company from King's College London, was established by Professor Paul Sharpe
Autologous wound healing	CellTran Ltd	Yorkshire	University of Sheffield spin-out company
Determination of the manufacturability of tissue-engineered bone implants	University of Oxford	South East	Dr Jan Czernuszka from the University of Oxford
Translating a new concept in injectable scaffolds into a regenerative medicine product	RegenTec	East Midlands	
Repair of torn meniscal cartilage using stem cell bandage integration technology	University of Bristol	South West	Professor Anthony Hollander from the University of Bristol

Source: Wellcome Trust

- 6.13 Scottish institutions or companies have not won any awards under this scheme to date.
- 6.14 The Wellcome Trust also makes strategic awards to research groups. Only one strategic award has been made to stem cell research to date, which went to the Wellcome Trust Stem Cell Research Centre at the University of Cambridge.
- 6.15 A second source of translational funding is the UK Stem Cell Foundation. The Foundation has made five awards to date, two in London and three in Scotland (Eye Pavilion and Royal Infirmary, the University of Edinburgh, and the University of Edinburgh with the Scottish National Blood Transfusion Service). Scottish institutions have also won the bulk of the funding under these awards.
- 6.16 In addition to these sources, an analysis was carried out on stem cell-related clinical trials recorded under the UK Clinical Trials database.

Table 6-4 Stem cell-related clinical trials identified in the UK

Region	Number of trials
East Midlands	6
London	6
South West	3
Yorkshire	3
West Midlands	2
North East	1
South East	1
Wales	1

Source: UK Clinical Trials Gateway/SQW analysis

- 6.17 There appears to be some correlation between translational activity and identified research strengths, with the East Midlands and London both leading on a substantial number of trials. However, the South West and Yorkshire, identified to date as being less research intensive, also lead on a number of trials. Scotland is notable for not leading on any clinical trials – at least according to this source.

Translational activity – European level

- 6.18 Translational activity is difficult to measure in the first instance as not all activity will proceed through the clinical trials route, and even where it does, there is not comprehensive reporting on the early stages of development. It becomes still more difficult when attempting to measure across countries.
- 6.19 The European Commission has instituted an EU-wide database of clinical trials, however, currently this is confidential. We would anticipate that this situation will change in the near future following pressure from governmental and non-governmental actors.

Translational activity – international level

- 6.20 The United States also compiles a database of clinical trials, which is made available online.
- 6.21 The US currently has an estimated 1,573 clinical trials involving some aspect of stem cell work. This is a gross figure, not adjusted for research which falls outside the definition used in the UK analysis.
- 6.22 The top five regions in the US for stem-cell related clinical trials were:
- California – 370
 - Maryland – 346
 - New York – 338
 - Washington – 288
 - Massachusetts – 231.
- 6.23 (N.B. a single trial can, and often does, take place in more than one location – on a state by state basis the total number of trials sums to a figure greater than 1,573)
- 6.24 There is some correlation between the top performing research regions and clinical trial activity – but the inclusion of Washington and Maryland (both understood to have strong hospital endowments) shows that clinical trials do not necessarily happen in those regions where research is most active. It is worth noting that almost all the American states had some degree of clinical trial activity (although many of these will be participants rather than lead sites), the vast majority in triple or double figures – only Wyoming (7) and Alaska (2) were in single figures.

Company base

Company base – UK level

- 6.25 Applying the definitions⁶ agreed between the study team and the steering group, the companies listed in Table 6-5 were identified in Scotland.

Table 6-5 Stem cell company base in Scotland at present

Company	Products/services	Status	Financial data	Employment data
Cellartis	<u>hES-CMCTM002</u> , cardiac cell line	launched		75+
	<u>hES-MPTM002.5</u> , mesenchymal cell line	launched		
	SCED TM 461 undifferentiated HES	launched		
	HES laboratory reagents	launched		
Geron	Cardiomyocytes	research		0-5
	Hepatocytes	research		
	Pancreatic Islets	research		
	Osteoblasts/chondrocytes	research		
Roslin Cells	Stem Cell Production	development		
StemCell Services	Contract stem cell research	launched	£1-1.5 million turnover (2007 forecast)	6-24
Number of companies: 4	Number of products/services: 10	Research: 4 Development: 1 Launched: 5		

Source: SQW

- 6.26 There are issues of definition around what is to be counted as a stem cell company – especially around the eligibility of the larger contract research organisations. For the development of the sector in Scotland, a wider definition can be used that takes in related companies such as Invitrogen, Angel Biotechnology or CXR Biosciences as these are important to the overall health of the industry. However for consistency in national and international comparisons the narrower definition is used.

⁶ Tools to discover, make, produce, validate and sell stem cell therapies shall include the cell lines, the media and growth factors, scaffold materials to support the growth of stems cells the vessels to incubate the cells, methods to recover stem cells from the body and to store them, methods and processes to expand stem cell lines, in vitro and in vivo toxicology testing of stem cell therapies, clinical trials of SCT, clinical trials production, other regulatory activity related to bringing stem cells to market, commercial production of stem cell products and the associated tools, storage and transport, commercial sales (including overseas sales where the company originates and operates from Scotland). The Stem Cell Therapy could be aimed at improving either human and or animal health. Tools to discover, make, produce, validate and sell drug research and development based on stem cell therapies shall include the cell lines, media growth factors and scaffold materials required to support the growth of stem cells for use in drug discovery, drug development and regulatory testing, methods to analyse stem cell activity including diagnostic techniques (including those used for human and animal health), imaging, chemical, biochemical and genetic analysis, contract research using these materials whether that be in vitro, in vivo or clinical work.

- 6.27 A similar definition was applied to three English regions where the findings of the research review, showed that there was significant activity occurring. These regions were: the East of England, London and the East Midlands.
- 6.28 Table 6-6 compares the Scottish company base with the three strongest English regions.

Table 6-6 Scottish company base compared with East of England, London and East Midlands			
Region	Number of companies	Number of products	Stage of development
Scotland	4	10	Research: 4 Development: 1 Launched: 5
East of England	5	14	Launched: 14 (data on products in research or development not known)
London	5	9	Research: 1 Development: 5 Launched: 4
East Midlands	2	4	Research: 0 Development: 4 Launched: 0

Source: SQW

Company base – European level

- 6.29 The findings from the analysis of EU-wide research show that stem-cell research is occurring across the continent, including in the largest EU states of Germany, France, Spain and Italy. This makes it much more difficult to arrive at a tractable way of identifying and analysing the EU level company base as we cannot easily identify “hot-spot” regions and then subsequently identify companies through their regional stem cell or regenerative medicine networks.
- 6.30 We have reviewed the Medicon Valley initiative (some 345 life sciences companies in Denmark and Sweden) and the company base in Baden-Württemberg. Table 6-7 below compares the identified company base with that in Scotland:

Table 6-7 Stem cell company base in Medicon Valley and Baden-Württemberg compared with Scotland					
Region	Number of companies	Number of products/services identified	Products/services at research stage	Products/services at development stage	Products/services launched
Medicon Valley	7	9	0	3	6
Baden-Württemberg	4	6	1	2	3
Scotland	4	10	4	1	5

Source: SQW analysis

Company base – international

6.31 A similar exercise was carried out for the strong stem cell research regions of Northern and Southern California and Massachusetts.

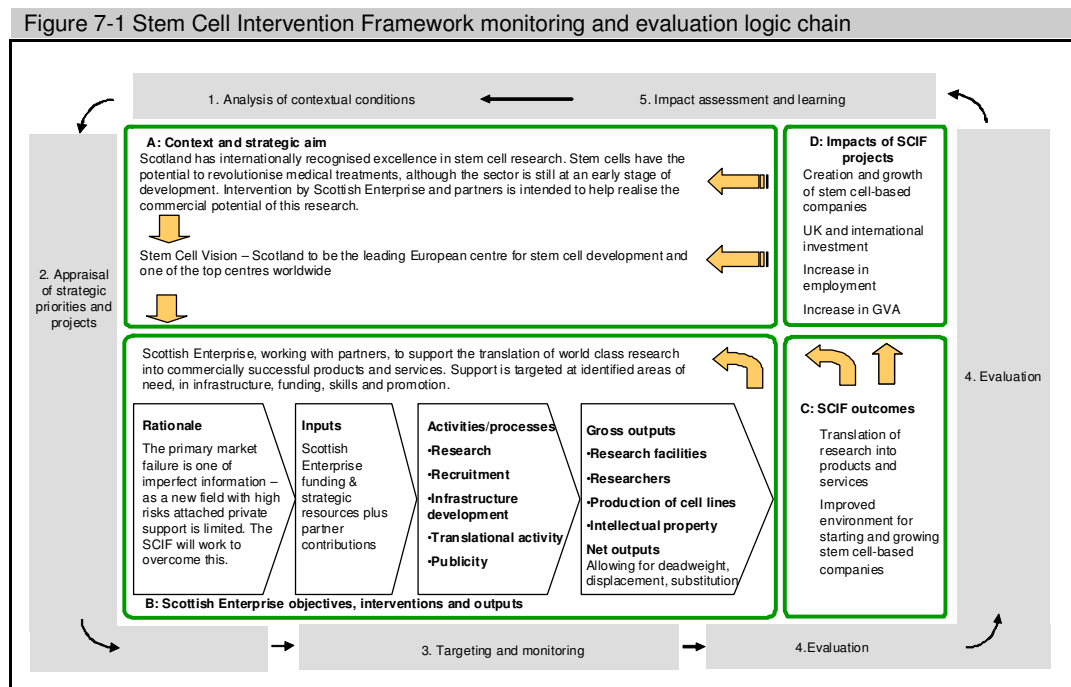
Table 6-8 Stem cell company base analysis - US regions compared with Scotland

Region	Number of companies	Number of products/services identified	Products/services at research stage	Products/services at development stage	Products/services launched
Massachusetts	14	36	3	12	21
Northern California	8	9	0	7	2
Southern California	9	21	4	8	9
Scotland	4	10	4	1	5

Source: SQW analysis

7: Monitoring and evaluation plan

- 7.1 This Chapter sets out the monitoring and evaluation plan for the Stem Cell Intervention Framework. The plan is derived from a logic model that describe the theory, assumptions and evidence underlying the rationale for the programme and the way in which it is expected to deliver outcomes and impacts.⁷
- 7.2 All logic models are based around the causal sequence between objectives, inputs/activities and outcomes/impacts as shaped by the external factors that inform the policy purpose and affect its outcomes. There are sources of official advice on these matters, most notably the Treasury’s Green Book and FABRIC guides.⁸ Figure 2-1 has been designed by SQW by combining the logic model structure used by the Innovation Network⁹ with the building blocks suggested by the purpose and operation of the SCIF set out in the previous section.



Source:

- 7.3 The logic model has four building blocks.

⁷ WK Kellogg Foundation; *Logic Model Development Guide*; January 2004 -

<http://www.wkkf.org/Pubs/Tools/Evaluation/Pub3669.pdf>

See also the Handbook of Practical Program Evaluation (2nd Edition, 2004) edited by Wholey, Hatry and

Newcomer - [http://www.amazon.ca/gp/reader/0787967130/ref=sib_rdr_zmout/701-7450422-](http://www.amazon.ca/gp/reader/0787967130/ref=sib_rdr_zmout/701-7450422-6151543?ie=UTF8&p=S001#reader-page)

[6151543?ie=UTF8&p=S001#reader-page](http://www.amazon.ca/gp/reader/0787967130/ref=sib_rdr_zmout/701-7450422-6151543?ie=UTF8&p=S001#reader-page)

⁸ HMT Green Book (2003) - [http://www.hm-](http://www.hm-treasury.gov.uk/economic_data_and_tools/greenbook/data_greenbook_index.cfm)

[treasury.gov.uk/economic_data_and_tools/greenbook/data_greenbook_index.cfm](http://www.hm-treasury.gov.uk/economic_data_and_tools/greenbook/data_greenbook_index.cfm) - and Choosing the Right

FABRIC (2001) - [http://www.hm-](http://www.hm-treasury.gov.uk/documents/public_spending_and_services/publicservice_performance/pss_perf_pischeck.cfm)

[treasury.gov.uk/documents/public_spending_and_services/publicservice_performance/pss_perf_pischeck.cfm](http://www.hm-treasury.gov.uk/documents/public_spending_and_services/publicservice_performance/pss_perf_pischeck.cfm)

⁹ Innovation Network, *Logic Model Workbook*, 2005 -

https://www.innonet.org/client_docs/File/logic_model_workbook.pdf

- A. The first block describes the context in which SCIF has to work – the policy context as well as national and regional conditions.
- B. This is the block in which the SCIF projects have their objectives, functions and outputs defined, planned and targeted. It includes considerations of process – how effectively and efficiently SCIF services are delivered – as well as outputs. This is also the block where SE is most likely to be able to exercise its strategic added value,¹⁰ and where contractual monitoring will be the most appropriate method of assessing progress.
- C. Evaluation will be an important way of determining progress in the third block of the framework because the effect on third parties will need to be examined here in order to translate the gross outputs generated by SCIF project activities into net outputs (i.e. after allowance for deadweight, displacement and multipliers) and into outcome measures.
- D. The focus of the final building block is on impact assessment. It is the one at most distance from the control and influence of SE and the SCIF and, yet, it is the stage in the assessment at which attempts need to be made to assess the economy wide impact of the SCIF interventions. While definitive conclusions may be difficult to draw, it should be possible to assess the ‘scale’ of the contribution of the SCIF against the changes in the conditions that gave rise to the services in the first place.

Performance assessment framework in practice

A: Business environment indicators

- 7.4 Table 7-1 sets out the indicators that we suggest could be used to establish the contextual conditions for the Stem Cell sector. The indicators are those used to populate Block A of Figure 7-1.

Indicator	Source and comments
Human capital	Maintain high level of human capital as measured by existing standards, such as the Research Assessment Exercise. Retain and attract high-quality human capital.
Physical capital	Progress on completion and occupancy levels in those projects with a physical infrastructure component.
Intellectual capital	Levels of competitive funding won by Scottish institutions for stem cell research as compared to peer regions.
Financial capital	Numbers of potential investors visiting and interacting with the sector.

¹⁰ Eight ‘tests’ of the presence of strategic added value are proposed in a technical note by the LDA and SEEDA on behalf of regional development agencies, i.e. if the activity of the organisation ...:

- a) Creates confidence in the prospects for regional growth
- b) Provides strategic leadership (of regional partners and stakeholders)
- c) Exerts a strategic influence (over key partners and stakeholders)
- d) Levers in investment from other sources
- e) Develops synergy (in activity of RDA partners, stakeholders and target audiences)
- f) Stimulates a scaling up of beneficial activity
- g) Enhances the quality of a desirable regional economic activity
- h) Encourages engagement in the regional strategy

Indicator	Source and comments
Market capital	In the longer term, levels of private investment entering the sector.
	Levels of FDI into the sector.
	New collaborations with overseas partners.
	Longer-term, the levels of exports.
Social capital	Level of useful activity within network.
	Satisfaction ratings by network members.
	Number and intensity of contacts with other networks.

Source: Scottish Enterprise/SQW

B: Activities and outputs

7.5 Table 7-2 relates to Block B of Figure 7-1 and sets out the measures used to assess SCIF activities and the outputs. These measures are the core monitoring requirements for SE and partners.

Table 7-2: Activities and Outputs Indicators

Indicator	Source	Comments
Activities		
Research group activity	Generated by institutions active in stem cell research	Indication of the intensity and extent of stem cell-related research taking place in Scotland (and which can usefully supplement departmental performance data). Also feeds into Human Capital measure.
Development of research infrastructure	Projects with a physical infrastructure component	
Provision of space for private companies	Projects with a physical infrastructure component	
Development of manufacturing facilities	Projects with a manufacturing component	
Development of cell lines	Projects involving the production of stem cell lines	
Outputs		
Facilities for researchers		Measured by number of researchers accommodated
Researchers recruited		Count of number of new researchers recruited to stem cell-related groups
Space for commercial firms		Measured by square metres of space available for occupancy by private firms
Manufacturing facilities		Measured by square metres of space devoted to manufacturing activity

C: Outcomes

7.6 Our proposal for Block C of Figure 7-1 is that it should be populated by the following kind of outcome measures:

Table 7-3: Outcome Indicators

Indicator	Source	Comments
Outcomes		
Retention/attraction of leading researchers	Projects employing research staff	Leading researchers are considered to be important to the continued success of Scottish stem cell research. "Leading" is a qualitative measure, but can include leadership of a research group, principal investigator status, or funding awards.
Improved collaboration between research and company base	Projects linking research base with companies involved in stem cell-based	Measured through flow of Scottish stem cell research activity into products and services launched.
Increased investment attracted	Data to be obtained through individual SCIF projects, the SSCN and media.	Measured through tracking private investment (both UK and overseas) in the Scottish stem cell sector
New products and services developed from Scottish research	Projects committed to producing new products and services	The launch of new products and services will be the first indication of successful translational activity.
Development of stem cell specific manufacturing technologies	Projects with a stem cell manufacturing objective	Achieving the commercial-scale production of stem cells
Availability of human-derived stem cells for Scottish companies	Projects producing stem cell lines for uptake by others	Stem cell lines considered to be an important intermediary step for the development of products and services
Scotland becoming an attractive location for clinical trials of stem cell-derived treatments	Clinical trial registration data	May require Scottish researchers being alerted to the need to ensure that all relevant trials are recorded.
Increased interactions between Scottish stem cell community and other organisations and networks in the UK and globally	SSCN	SSCN is a important bridge in the SCIF between research excellence and wider uptake and commercialisation of research.

D: Impacts

7.7 The final component of the performance assessment framework, Block D, is populated in our proposal by the following intermediate and final impact indicators.

Table 7-4: Impact Indicators

Indicator	Source	Comments
Intermediate impacts		
Number of discoveries entering pre-clinical phase	Projects producing stem cell-based therapies	Measured according to progress, e.g. Phase 1, 2 etc.
Occupancy of premises by private companies	Projects with space provision for private companies	Measured by % of square metres occupied by commercial firms
Number of stem cell discoveries licensed	Projects making research available for license	

Indicator	Source	Comments
Production of stem cell lines	Companies producing stem cell lines for use	Simple count of number of stem cell lines
Uptake of stem cell lines	Companies producing stem cell lines for use	Measurement of the number of researchers or companies acquiring and using these stem cell lines
Number of spin-out companies created	Research projects giving rise to the creation of commercial companies	Simple count of company creation
Number of products at development stage	Projects producing medical devices	Count of devices at a development (pre-market) stage
Number of products launched	Projects producing medical devices	Count of devices launched into the marketplace
Number of services in development phase	Projects giving rise to stem cell-based services	Count of services at a development (pre-market) stage
Number of services launched	Projects giving rise to stem cell-based services	Count of services launched into the marketplace
Progress of Scottish based regenerative therapies into Phase 1 clinical trials	Projects moving research into clinical trials	Phase 1 is the initial indication. Once SE and partners are alerted to this development, the subsequent progress of the trial into succeeding phases can be tracked
Impacts		
Increase in number of Scottish-based stem cell companies	SSCN	
Increase in employment in Scottish stem cell company base	Companies	Likely to require canvassing of companies themselves to secure reliable data.
Increase in Scottish GVA attributable to the stem cell company base	Companies	Will require canvassing of companies themselves to secure reliable data for GVA analysis.

National and International Comparators

7.8 The national and international comparators are built up from a series of data sources.

7.9 At a national level, these include:

Table 7-5 National comparator data sources

Research	Medical Research Council
	Biotechnology and Biological Sciences Research Council
	UK Stem Cell Foundation
Translational	UK Clinical Trials Gateway
	Wellcome Trust
	UK Stem Cell Foundation
Company base	Following the identification of the strongest performing regions through review of research and translational

awards, these regions are explored using membership networks and listings of life sciences companies.

For instance, in Scotland, the SE Lifesciences Sourcebook and the Scottish Stem Cell Network were used. In the East of England, the East of England Stem Cell Network was drawn upon.

Additional company activity may also be identified from research or translational awards data.

Once companies have been identified, company website, literature and media references are reviewed to identify:

- Product/service pipeline
- Employment data (if available)
- Investment data (if available)

Source: SQW

7.10 At an international level, data sources are less comprehensive. This report drew on a number of sources.

Table 7-6 International comparator data sources

Research	EU Research and Development Framework (now in its 7 th generation)
	National Institute of Health awards (United States)
Translational	National Institute of Health ClinicalTrials.gov
Company base	As with national comparators, following the identification of the strongest performing regions, membership networks and listings of life sciences companies are explored.
	Once companies have been identified, company website, literature and media references are reviewed to identify:
	<ul style="list-style-type: none"> • Product/service pipeline • Employment data (if available)
	Investment data (if available)

7.11 In repeating this exercise, a staged process should be followed, as suggested in Table 7-7. The input of an expert familiar with the field should be used in overseeing the analysis, although the data collection can be undertaken by generalists.

Table 7-7 Developing the national/international comparators

Phase	Comment
Review of sources	Check and update sources above – for instance EU clinical trials activity may have become available in the interim, for instance, the MRC may have started to make awards for stem cell translational activity.
Data collection	Gather available data on awards and clinical trials. The majority of this data will be available online from the institutions' websites.
Data analysis	Review of data with input from subject expert. These data will yield relative performance on research and translational activity.

Phase	Comment
Company review	<p>Once strongly performing regions are identified, the local networks for life sciences can be mined to uncover participating stem cell companies.</p> <p>Data on company activity can then be sought from company websites (good for numbers and stage of development of products and services) and secondary sources such as Companies House and industry news sources (potentially useful for employment numbers and financial data).</p>
Baseline review	<p>Finally, the baseline for Scotland can be revisited. This will include inputs from the SSCN on issues such as intellectual property, collaborations etc.</p>

Source: SQW

8: Conclusions and recommendations

Conclusions

- 8.1 Of all Scottish Enterprise’s interventions, the Scottish Stem Cell Intervention Framework lies at perhaps the greatest extreme of the risk/return matrix, with potentially enormous opportunities balanced by great uncertainties. SE has taken on a risk that the private sector has been unwilling to take by seeking to support the translation of leading stem cell research in Scotland into commercial products and services.
- 8.2 These uncertainties cannot be eliminated or hedged against, only actively managed. Clear “line of sight” to commercial success is probably impossible to achieve for now. The monitoring and evaluation framework can help by:
- Improving visibility as to the type and extent of research moving into the development phases
 - Identifying gaps in the value chain that may need to be addressed
 - Identifying emerging opportunities that are being exploited elsewhere.
- 8.3 Given the distance the sector still has to travel before it becomes a mature industry sector it is not yet appropriate to place mainstream indicators of performance against it. Instead, we have proposed a series of intermediate outcomes and impacts that will indicate the direction of travel, along with measurements of the development of the surrounding business environment.
- 8.4 While these indicators do not provide a clear causal linkage between the current position and the national objective of developing a commercially successful stem cell sector, across the range of activity supported, they are necessary for the achievement of this objective. Where progress is being made under these measures, partners will at least have a degree of reassurance that momentum is being maintained and Scotland’s competitive position is not being eroded.
- 8.5 In the longer-term, perhaps five to ten years from now, the sector can be expected to have matured and perhaps separated into mainstream lines of activity and more experimental lines of inquiry. At this stage, it will be appropriate to apply more conventional measures of progress and impact.
- 8.6 We would offer one caveat to this. The national and international comparators research shows that Scotland continues to hold a strong place nationally in quality of research, and that Scottish research groups are competing successfully to win translational funding (taken to be a proxy for translational activity). However development through to clinical trial stages is less evident. The comparators research reveals that there is a growing level of clinical trial activity internationally and that companies are achieving a degree of commercial success with stem cell technology today, albeit not yet with “block-buster” products. The participants in the

SCIF should remain alert to the possibility of early commercial wins from their research as well as working towards the successful translation of research into applications.

Future work

- 8.7 While this study was not a conventional evaluation of the stem cell sector in Scotland, the opportunity to speak to so many of the participants was also an opportunity to flag up areas that may require further exploration. From consultations and from group discussions, the issues that are currently of greatest interest to successfully advancing the sector in Scotland are:
- 8.8 **Availability of staff for work in translational research and development** – there was some question raised by participants as to the attractiveness of translational activity for researchers on an academic career track. However, it is currently unclear how much of an issue this might be or what its implications are for the sector.
- 8.9 **Developing a proof of concept for current research** – researchers consider that for many of the main lines of stem cell enquiry the proof of concept has still to be established. This area may lie outside of SE's remit.
- 8.10 **The role of clinical trials** – clinical trials will form an important step in the translation of research through to commercial success. At the moment, the secondary data appears to show that stem cell related trials are predominantly taking place in other parts of the UK (although these trials may only involve stem cell treatments in a secondary role, and the completeness of the data has been questioned). The current logic of the SCIF is for trials to take place in Scotland, it may be worth reviewing:
- Whether there are particular benefits to clinical trials of Scottish-derived research being carried out in Scotland?
 - If there are benefits, are there currently constraints to these trials taking place, or in attracting trials by non-Scottish researchers?
- 8.11 **The role of intellectual property in the sector** – from discussions with IP specialists Marks&Clark (whose clients include stem cell companies) it is clear that investors will continue to value those companies who have clearly secured their IP in a defensible form. From discussions with consultees, there do appear to be some issues as to how this will be done in the UK, particularly where stem cell lines have been made freely available to all.
- 8.12 **Establishing links with corporate investors** – there is currently an investment deficit due to private investors being unclear as to what they are investing in, and companies being unable to provide a convincing business model by which investors might recoup their investment. Recent investments by Pfizer in Cambridge, East of England and by GSK in Massachusetts, United States shows that there is now some movement in this area. In conjunction with SDI, SE could explore the attractiveness/constraints to similar investments being secured for Scotland.
- 8.13 **Route to commercialisation** – the SCIF is helping to support extensive university activity in stem cell research and translation, but there may be a potential mismatch between SE's

aspirations and the organisational logic of the universities' own paths to commercialisation. For instance, licensing (including to companies outside of Scotland) may be preferred to creating companies locally to develop discoveries. It may be worth exploring how the commercialisation of stem cell research is envisaged to happen by all parties to ensure that there is alignment of ambition within the SCIF.

Annex A: Scottish Stem Cell base

Current position, August 2008

A.1 The intention is for Scotland's progress in stem cell activity to be monitored periodically. The baseline below sets out the current position in Scotland, based on available data, in 2008. The baseline covers the following items:

- Research
 - MRC/BBSRC research awards
 - Patents
- Translational activity
 - Wellcome Trust awards
 - UK Stem Cell Foundation awards
 - Clinical trials
- Company base
 - Number of companies
 - Number of products

Research

MRC/BBRC research awards

Table A-1 UK-level stem cell research activity, MRC/BBSRC competitive research awards (October 2004- March 2008)

	MRC/BBSRC awards
London	12
Scotland	6
East Midlands	6
East of England	5
West Midlands	3
South East	3
North West	2
South West	1
Wales	1
Yorkshire	1

Source: Medical Research Council/ Biotechnology and Biological Sciences Research Council

Patents

A.2 Patent data – stem cell patents awarded is assumed to be zero in 2008.

Translational activity

Wellcome Trust research awards

8.14 No awards made to Scottish institutions up until 2008.

UK Stem Cell Foundation awards

A.3 UK Stem Cell Foundation – three out of five awards to date (2008) have gone to Scotland

Clinical trials

Table A-2 Stem cell-related clinical trials identified in the UK (1994-2008)

Region	Number of trials
East Midlands	3
London	3
South West	3
Yorkshire	1
West Midlands	1
Wales	1
East of England	1

Source: UK Clinical Trials Gateway/SQW analysis

A.4 No stem cell clinical trials identified in Scotland as of 2008.

Company base

Number of companies

Table A-3 Stem cell company base in Scotland, August 2008 (using narrow definition)

Company	Comment	Financial data	Employment data
Cellartis	Registered 11/06/07 – company base in Sweden	Accounts filed in Sweden	Not stated
Geron Bio-Med	Registered 01/10/1997	Turnover £149,000 Cost of sales £255,000 Gross loss (£106,000) Interest receivable and similar income £194,000 Retained profit £61,000 (all December 2006)	0-5 (Lifesciences Sourcebook)
Roslin Cells	Registered 16/09/05	Abbreviated accounts only filed. Total assets less current	Not stated

Company	Comment	Financial data	Employment data
		liabilities - £173,860	
Stem Cell Services	Registered 18/04/06	Share transactions only recorded to date	6-24 (Lifesciences Sourcebook)
Number of stem cell companies: 4			

Source: Companies House and Scottish Lifesciences Sourcebook

Number of products/services

8.15 In 2008, the products/services position was assessed as:

- Number of products/services: 10, of which
 - 4 were at research stage
 - 1 was in development
 - 5 had been launched

Business environment mapping

A.5 The Scottish Stem Cell Network will be best placed to undertake the business environment mapping obtained through its regular networking function. As these measures have no published sources, it is not possible to establish a baseline through desk-based research. Instead, the SSCN should seek to measure the stem cell business environment from the current period onwards.

Table A-4 Business environment mapping indicators

Asset	Measurement of progress	Current status
Human capital	Maintain high level of human capital as measured by existing standards, such as the Research Assessment Exercise. Retain and attract high-quality human capital.	Eight research groups active (The Institute for Stem Cell Research (ISCR), University of Edinburgh ; The Centre for Regenerative Medicine, University of Edinburgh ; The Centre for Reproductive Biology, University of Edinburgh ; John Hughes Bennett Laboratory, Division of Oncology, University of Edinburgh ; MRC Centre for Inflammation Research, University of Edinburgh ; Roslin Institute ; Section of Experimental Haematology & Haemopoietic Stem Cells, University of Glasgow ; The Shiels Group, Department of Surgery, University of Glasgow ; The Scottish National Blood Transfusion Service ; and Division of Economics and Enterprise, Glasgow Caledonian University – Source: Life Sciences Scotland) Three leading researchers: Professor Ian Wilmut, Roslin Institute Professor Tessa Holyoake, University of Glasgow Paul de Souza, Roslin Institute

Asset	Measurement of progress	Current status
		(Source: Life Sciences Scotland)
Physical capital	Progress on completion and occupancy levels in those projects with a physical infrastructure component.	
Intellectual capital	Levels of competitive funding won by Scottish institutions for stem cell research as compared to peer regions.	Scottish Centre for Regenerative Medicine approved, expected to be complete by 2011.
Financial capital	Numbers of potential investors visiting and interacting with the sector. In the longer term, levels of private investment entering the sector.	Current level of investors visiting and interacting is unknown. Recommend SDI/SSCN monitor this.
Market capital	Levels of FDI into the sector. New collaborations with overseas partners. Longer-term, the levels of exports.	Limited baseline data. Location of Cellartis R&D facility in Dundee, 2007 is the most notable item.
Social capital	Level of useful activity within network. Satisfaction ratings by network members. Number and intensity of contacts with other networks.	No data available at present, recommend SSCN establish a baseline and monitor progress.

Position in 2003

- A.6 The Scottish Stem Cell Framework has grown organically from 2003 onwards. The baseline below shows the position in Scotland immediately prior to the first project launched under the Framework.

Research

- A.7 The Medical Research Council's database of awards goes back only until 2004. The BBRSC database can be interrogated further back. These data are displayed in the table below

Table A-5 UK-level stem cell research activity, BBRSC competitive research awards (January 1999 - December 2003)

	BBRSC awards
Scotland	7
East of England	7
West Midlands	7
Wales	5
North East	5
London	4
South West	4

BBSRC awards	
North West	2
East Midlands	1
South East	1
Yorkshire	1

Source: Biotechnology and Biological Sciences Research Council

Translational activity

Table A-6 Stem cell-related clinical trials identified in the UK (1999-2003)

Region	Number of trials
East Midlands	2
London	1
South West	1
Yorkshire	2
West Midlands	1
Wales	1
East of England	2

Source: UK Clinical Trials Gateway/SQW analysis

Company base

Table A-7 Stem cell company base in Scotland, 2003

Company	Comment	Financial data	Employment data
Geron Bio-Med	Registered 01/10/1997	Turnover £145,000 Cost of sales £139,000 Profit £3,000	Not stated
Stem Cell Sciences	Registered 16/09/05	Abbreviated accounts only filed. Total assets less current liabilities - £173,860	Not stated

Source: Companies House

Progress between 2003 and 2008

- A.8 Between 2003 and 2008, on available indicators, the progress of the Scottish stem cell sector was as follows:

Table A-8 Progress in the Scottish stem cell sector between 1999-2003 and 2004-2008

Indicator	Progress
Number of MRC/BBSRC awards	Slight decrease from a 15.9% share in 2003 to 15.0% share in 2008
Number of clinical trials	No change, no clinical trials in either period
Number of companies	Net increase of 2 to 4 companies

Source: SQW

Annex B: UK-level comparators

Research activity

- B.1 UK research activity has been explored through four sources: Medical Research Council, the Biotechnology and Biological Sciences Research Council, the Wellcome Trust and the UK Stem Cell Foundation..
- B.2 These provide the following rankings of research activity.

Table B-1 Number of MRC/BBSRC research awards for stem cell research, Oct/Nov 04 to Feb/March 08

	Oct - Nov 04	Jan - Feb 05	May - June 05	Oct - Nov 05	Feb - Mar 06	June - July 06	Oct - Nov 06	Feb - March 07	June - July 07	Oct - Nov 07	Feb - March 08	Total
London	1	1				3	1		4	1	1	12
Scotland	2			1		1	1				1	6
East Midlands		1	1		1			2	1			6
East of England					1	1	1			1	1	5
West Midlands	1				1					1		3
South East		1					1			1		3
North West										1	1	2
South West										1		1
Wales											1	1
Yorkshire											1	1

Source: MRC/BBSRC, SQW analysis

- B.3 Table B-2 gives the amount of MRC/BBSRC awards.

Table B-2 Total stem cell research funding awarded by MRC/BBSRC, Oct/Nov to Feb/March 08

Region	Total funds awarded	Percentage of funds awarded
London	£9,374,152	35.1
East of England	£5,102,872	19.1
Scotland	£3,519,021	13.2
East Midlands	£2,206,106	8.3
Yorkshire	£2,101,812	7.9
South East	£978,210	3.7
Wales	£705,536	2.6

Region	Total funds awarded	Percentage of funds awarded
North West	£704,954	2.6
West Midlands	£679,008	2.5
South West	£490,957	1.8
North East	£484,228	1.8
North West	£363,520	1.4
Total	£26,710,376	100.0

Source: MRC/BBSRC, SQW analysis

Translational activity

- B.4 Three UK sources were used: Wellcome Trust and UK Stem Cell Foundation awards to undertake translational research, and available data on clinical trials
- B.5 As noted in the evaluation principles working paper, stem cells have been identified as an area where private support for translational work may be less likely to be forthcoming due to a variety of risk factors. Non-private sources, whether public or third sector, are therefore likely to assume greater importance. One directly applicable source of funding identified is the Wellcome Trust's Translational Awards are described as "response-mode funding designed to bridge the funding gap in the commercialisation of new technologies in the biomedical area." Five translational awards in the stem cells space have been identified to date.

Table B-3 Wellcome Trust translational awards to date

Title	Institution	Location	Comment
Tissue engineering of teeth	Odontis Ltd	London	Spin-out company from King's College London, was established by Professor Paul Sharpe t
Autologous wound healing	<u>CellTran Ltd</u>	Yorkshire	University of Sheffield spin-out company
Determination of the manufacturability of tissue-engineered bone implants	University of Oxford	South East	Dr Jan Czernuszka from the University of Oxford
Translating a new concept in injectable scaffolds into a regenerative medicine product	RegenTec	East Midlands	
Repair of torn meniscal cartilage using stem cell bandage integration technology	University of Bristol	South West	Professor Anthony Hollander from the University of Bristol

Source: Wellcome Trust

- B.6 Scottish institutions or companies have not won any awards under this scheme to date.
- B.7 The UK Stem Cell Foundation has made five awards to date.

Table B-4 UK Stem Cell Foundation awards				
Title	Field of research	Institution	Award	Region
Revision surgery employing stem cell technology	Inclusion of stem cells in the second hip replacement to improve bone regeneration	University College London and the Royal National Orthopaedic Hospital	£137,840	London
The treatment of heart disease using stem cell technology	Use of adult bone marrow-derived stem cells to treat patients by applying engineered stem cells into the site of the infarct within a very tight timeframe (4 hours) following a heart attack	University of London in collaboration with Barts Hospital and The Heart Hospital	£1m	London
Stem cell treatment to cure corneal blindness	Application of ex vivo limbal stem cells to address limbal stem cell deficiency	Eye Pavilion and Royal Infirmary, Edinburgh	£380,000	Scotland
The treatment of Liver Disease employing Stem Cells	Development of viable liver cells (hepatocytes) from embryonic stem cells to determine their value in the treatment of acute and chronic liver disease	University of Edinburgh	£1.7m	Scotland
Bone and cartilage repair employing stem cells	Two related projects deriving bone and cartilage forming cells from two distinct sources – human embryonic stem cells and autologous adult stem cells.	Edinburgh University and the Scottish National Blood Transfusion Service	£2.6m	Scotland

Source: UK Stem Cell Foundation

- B.8 Of the five awards, three have been awarded to Scottish institutions, the remaining two going to London-based organisations. The majority of the UKSCF funding has also gone to Scotland.
- B.9 In addition, an analysis was carried out on stem cell-related clinical trials recorded under the UK Clinical Trials database. The definition of a stem cell related trial used here is quite broad, and includes treatments where only some of the patients are receiving a stem cell based intervention.

Table B-5 Stem cell-related clinical trials identified in the UK (2000-2008)	
Region	Number of trials
East Midlands	5
London	4

Region	Number of trials
South West	4
Yorkshire	2
West Midlands	2
Wales	2
East of England	3

Source: UK Clinical Trials Gateway/SQW analysis

- B.10 There appears to be some correlation between identified research strengths, with the East Midlands and London both leading on a substantial number of trials. However, the South West and Yorkshire, identified to date as being less research intensive, also lead on a number of trials. Scotland is notable for not leading on any clinical trials – at least according to this source.

Table B-6 Stem cell-related clinical trials in the UK

Study domain	Hypothesis	Sponsor	Sources of funding	Institution	Region
Cancer: testicular	High-dose chemotherapy with peripheral blood stem cells	Department of Health	Christie Hospital Trust NHS	Christie Hospital Trust NHS	North West
Breast cancer	Peripheral blood progenitor support in patients with high risk breast cancer	Amgen	Amgen	Amgen	East of England
Breast	High-dose therapy, including peripheral blood stem cell support	Amgen	Amgen	MRC Clinical Trials Unit	East of England
Isachemic heart disease	Autologous bone marrow-derived cells for cardioprotection during heart surgery	University of Leicester and Glenfield Hospital	Cardiac Surgery Group	University of Leicester and Glenfield Hospital	East Midlands
Isachemic stroke	trial of granulocyte-colony stimulating factor in mobilising bone marrow stem cells in sub-acute stroke	University of Nottingham	Medical Research Council	Stroke Trials Unit	East Midlands
Isachemic stroke	Effects of granulocyte-colony stimulating factor and autologous bone marrow progenitor cells (STEMS)	University of Nottingham	The Stroke Association	University of Nottingham	East Midlands
Coronary heart disease	Autologous stem cells delivered percutaneously to the damaged myocardium	University Hospitals of Leicester NHS Trust	University Hospitals of Leicester NHS Trust	Glenfield Hospital	East Midlands
Acute lymphoblastic leukaemia	Application of haematopoietic stem cell transplantation	Barts and the London NHS Trust	Cancer Research UK	Royal London Hospital	London

Study domain	Hypothesis	Sponsor	Sources of funding	Institution	Region
Leukaemia	Autologous bone marrow rescue (ABMT or Peripheral Stem Cell Rescue)	Medical Research Council	Medical Research Council	University College Hospital	London
AL Amyloidosis	Feasibility of a Phase III study with stem cell transplantation	University College London	Clinical Trials Advisory and Awards Committee	Royal Free Hospital	London
Myeloid malignancies	Phase II trial of sequential treatment included reduced intensity conditioning allogeneic stem cell transplantation	Joint Research Office	Barts and the London NHS Trust	St Bartholomew's Hospital	London
Isachemic heart disease	Effects of granulocyte-colony stimulating factor and autologous bone marrow progenitor cells (STEMS2)	Barts and the London NHS Trust	The Heart Cells Foundation	The London Chest Hospital	London
Coronary artery bypass grafting	Efficacy of transplanted progenitor cells and coronary artery bypass grafting	Department of Health	Southampton University Hospitals NHS Trust	Southampton General Hospital	South West
Leukaemia	Includes evaluation of allogeneic stem cell transplantation	Cardiff University	Medical Research Council	University of Wales College of Medicine	Wales
Acute myeloid leukaemia and high risk myelodysplastic syndrome	Includes non-intensive allogeneic stem cell transplant	Cardiff University	Clinical Trials Advisory and Awards Committee	Cardiff University	Wales
Leukaemia	Prospective Phase III trial to compare the outcome of autologous stem cell transplantation with no further treatment in patients	Heart of England NHS Foundation Trust	Heart of England NHS Foundation Trust	Birmingham Heartlands Hospital	West Midlands
Rheumatoid arthritis	Autologous stem cell transplantation to investigate the pathogenic role of T-cells	Department of Health	Leeds Teaching Hospitals NHS/Arthritis Research Campaign	Rheumatology and Rehabilitation Research Unit	Yorkshire
Myelomatosis therapy trial	Effects of giving additional consolidation therapy from allogeneic stem cell transplantation	Clinical Trials Research Unit	Medical Research Council	Clinical Trials Research Unit	Yorkshire
Relapsed multiple myeloma	Role of second autologous stem cell transplant in consolidation therapy	Leeds Teaching Hospitals NHS	Cancer Research/Chugai Pharma	University of Leeds	Yorkshire
Leukaemia	Includes autologous bone marrow/peripheral	Medical Research Council	Medical Research Council	Leeds General Infirmary	Yorkshire

Study domain	Hypothesis	Sponsor	Sources of funding	Institution	Region
	blood stem cell support				

Source: UK Clinical Trials Gateway/SQW analysis

Company base

B.11 The 6th Framework Programme data was used to identify UK SMEs active in stem cell work.

Table B-7 English SMEs involved in 6th Framework programme

Company	Location	Region
Regentec Ltd	Nottingham	East Midlands
DanioLabs Limited	Cambridge	East of England
Ark Therapeutics Ltd	London	London
AlloStem	London	London
Orla Protein Technologies Ltd	Newcastle upon Tyne	North East
Dynal Biotech Ltd	Bromborough	North West
VASTox plc	Abingdon	South East
Oxford BioMedica Plc	Oxford	South East
Hybrid Systems Ltd.	Oxford	South East
Ideas3	Englefield Green	South East
Rapra Technology Ltd	Shrewsbury	South East
Oxford Biomaterials Ltd.	Newbury	South East
PROIMMUNE Limited	Oxford	South East
ReNeuron Ltd	Guildford	South East
Axordia Ltd	Sheffield	West Midlands
Pro-Cure Therapeutics Ltd	York	Yorkshire
Yorkshire Bioscience Limited	York	Yorkshire
Stem Cell Sciences*	Edinburgh	Scotland

*NB Since relocated to the East of England

Source: European Commission/SQW analysis

B.12 Based on the 6th Framework data, the South East appears as the strongest performer in SME involvement, with eight SMEs identified. The East of England and East Midlands, which were identified as strong regions in terms of research funding, have much lower instances of SME involvement. While these companies have been active, not all will meet the strict definition of a stem cell company as set out in Section 6.25.

B.13 Instead, based on their strong research performance, the company base of the regions of the East of England, London and the East Midlands was reviewed.

Table B-8 Company base in East of England, London and East Midlands

Region	Company	Product	Status	Financial data	Employment data
East of England	Miltenyi biotec	MACS Magnetic cell isolation	Launched		

Region	Company	Product	Status	Financial data	Employment data
East of England	Stem Cell Sciences	Neural Stem Cell	Launched	£593,000 turnover	
East of England	Stem Cell Sciences	Neurons	Launched	£4.94 million investment	
East of England	Stem Cell Sciences	Astrocytes	Launched		
East of England	Stem Cell Sciences	Osteoblasts	Launched		
East of England	Stem Cell Sciences	Pericytes	Launched		
East of England	Stem Cell Sciences	Embryonic Stem Cells	Launched		
East of England	Orthomimetic	Porous tissue material for bone and cartilage	Launched	£5 million raised in equity round (2006) Also, awards from UK Technology Strategy Board (£600k for tissue regeneration research, £700k for LigaMimetic)	
East of England	British Stem Cell Registry	Umbilical cord blood stem cells	Launched		
East of England	Cytomex	Stem Cell microRNA qPCR Panel	Launched		
East of England	Cytomex	CAMEO-4	Launched		
East of England	Cytomex	LUMENESC- for Mesenchymal Stem Cells	Launched		
East of England	Cytomex	CAMEO-96	Launched		
East of England	Cytomex	Human Proteins for Stem Cell Research	Launched		
London	Plasticell	High throughput cell screening	Launched		
London	Plasticell	Six embryonic cell lines	Development		
London	Vetcell/ Medcell	MS-Ten autologous stem cells for tendons	Development		

Region	Company	Product	Status	Financial data	Employment data
		(human)			
London	Vetcell/ Medcell	MS-Ten autologous stem cells for tendons (equine)	Launched		
London	Vetcell/ Medcell	Thermamatrix; bone scaffold	Development		
London	Vetcell/ Medcell	Colloss biomaterial	Launched		
London	Vetcell/ Medcell	Platelet Rich Plasma	Launched		
London	Odontis	Biotooth	Research		
London	Ophthaltec	Eye regenerative products	Development		
London	Bioceramic	Tissue scaffold	Development		
East Midlands	Regentec	space filling template to support tissue repair processes	Development		
East Midlands	Regentec	delivery vehicle for growth factors	Development		
East Midlands	Regentec	cell delivery vehicle	Development		
East Midlands	Evocell	platform technologies for autologous cell therapy	Development		
East Midlands	Evocell	derive pluripotent reprogrammed cells from somatic cells of domestic animals	Development		

Source: SQW

Annex C: European-level comparators

Research activity

- C.1 Research activity at EU level has been captured through the results of the 6th Framework Programme. This allows a comparison to be made right across the European Union in a way that levels out national differences in research or funding regimes – it also takes in non-EU countries, such as Israel, Norway and Switzerland which have well-developed research bases .

Table C-1 Involvement in stem cell research under the 6th Framework Programme

Country	Number of projects involved in	% share of total projects
Germany	83	11.4
England	71	9.8
France	65	9.0
Italy	61	8.4
Switzerland	48	6.6
Spain	46	6.3
Netherlands	43	5.9
Sweden	43	5.9
Belgium	38	5.2
Austria	29	4.0
Israel	26	3.6
Denmark	23	3.2
Finland	17	2.3
Scotland	16	2.2

Source: European Commission/SQW analysis

- C.2 Germany, France, and Italy are all strong performers under this measure – despite the received wisdom that they are less active in this research area. Scotland has a comparable level of involvement to Finland, but it is lower than other similarly sized countries such as Israel, Denmark, Sweden and Belgium. The review of researcher involvement (included in Annex B) shows a similar result.
- C.3 In terms of funding won, Scotland shows a similar ranking (although Finland moves up and Denmark comes down). Again, we see a strong performance from countries not previously identified as strong performers in stem cell research.

Table C-2 Stem cell funding allocations under the 6th Framework Programme (euros)

Country	Funding	Percentage share of awards
Germany	105,175,099	20.1
France	65,467,547	12.5
England	57,038,178	10.9
Italy	52,494,935	10.0
Sweden	34,257,765	6.6
Switzerland	30,068,734	5.8
Netherlands	29,548,760	5.7
Spain	25,372,238	4.9

Country	Funding	Percentage share of awards
Belgium	24,045,103	4.6
Austria	14,768,402	2.8
Israel	14,155,766	2.7
Finland	11,684,683	2.2
Denmark	9,809,976	1.9
Scotland	8,847,210	1.7

Translational activity

- C.4 The European Commission has instituted an EU-wide database of clinical trials, however, currently this is confidential. We would anticipate that this situation will change in the near future following pressure from governmental and non-governmental actors.

Company base

- C.5 The findings from the analysis of EU-wide research show that stem-cell research is occurring across the continent, including in the largest EU states of Germany, France, Spain and Italy. This made it much more difficult to arrive at a tractable way of identifying and analysing the EU level company base on a regional basis.

Table C-3 Involvement of SMEs and Independents in the 6th Framework Programme

Country	Number of instances of SME participation	Number of instances of Independent participation
Germany	37	14
France	26	5
England	18	4
Sweden	17	3
Italy	16	1
Netherlands	14	
Belgium	12	4
Spain	12	1
Switzerland	9	2
Denmark	8	4
Austria	7	1
Finland	5	
Scotland	5	

- C.6 Scotland is at the lower end of the lead regions, in terms of company involvement, and this representation is entirely accounted for by one company, Stem Cell Sciences (which has since relocated to the East of England).

- C.7 Germany shows the highest level of SME involvement. There is no one focus to German company involvement, although Heidelberg (Baden-Württemberg), Munich (Bavaria) and Konstanz (also Baden-Württemberg) have higher than average representation. Germany also has the highest participation by Independents, which can include larger companies. Of the 14 German Independents identified, 13 of them were large companies - Miltenyi Biotec and Bayer both appearing more than once.
- C.8 The next largest country in terms of company participation was France, with 26 occurrences of SME involvement and 5 Independents. Marseille had the greatest concentration of SMEs, followed by Lyon and Nantes. All four of France's Independents were large companies.
- C.9 England came third in terms of SME involvement on this measure. The English experience is explored more thoroughly in the national level section, but it is worth noting that of the four English Independents, two were large firms – Unilever and AstraZeneca
- C.10 While the 6th Framework Programme data has many advantages as a means of searching across Europe, it is still not a perfect measure. However the strength of company involvement, including by many countries seen in some media presentations as disconnected from the forefront of stem cell activity, appears significant. This evidence suggests there is strength in depth in the company base in many European countries, and not just in those with a high stem cells profile.
- C.11 We have reviewed the Medicon Valley initiative (some 345 life sciences companies) and Baden-Württemberg in Germany. The Table below compares the identified company base with that in Scotland.

Table C-4 Company base in Medicon Valley and Baden-Württemberg compared with Scotland

Region	Number of companies	Number of products/services identified	Products/services at research stage	Products/services at development stage	Products/services launched
Medicon Valley	7	9	0	3	6
Baden-Württemberg	4	6	1	2	3
Scotland	4	10	4	1	5

Source: SQW analysis

- C.12 The following Tables give the detail of the company base in these regions, obtained from industry associations and through company websites.

Table C-5 Company base in Medicon Valley (Denmark and Sweden)

Company	Products/services	Status	Financial data	Employment data
Biora	Emdogain	Launched	CHF 714 million (regeneration products make a small amount of this turnover) NASDAQ	80+

Company	Products/services	Status	Financial data	Employment data
			listed	
	Boneceramic	Launched		
Bone Support	Ceracement substitute Injectable Bone	Launched	315 SEK million investment (November 2006)	21+
Cardiicapacity	3D structures for heart cells	Development		
Interface biotech	Cartilink	Development	Invested in (15%) by Coloplast in 2007	7+
Millimed	Cardiac support structure	Development	18 million euro investment (Danish Growth Fund, American Advent International)	45+
Stemcare	Umbilical Stem Cell Storage	Launched	Pre-seed round in 2002 Seed round in 2003 Series A round in 2004 (DKK 11.4 million) Series A bridge round in 2006 (DKK 1.0 million)	11+
Tigran	Porous bone Support	Launched		
	Ortix for orthopaedic applications	Launched		
Number of companies: 7		Number of products/service: 9		

Table C-6 Company base in Baden-Württemberg

Company	Products/services	Status	Financial data	Employment data
CellGenix Technologie Transfer GmbH	CartiGro - cartilage defects in the knee joint	Launched		45 employees
	CellGro® Kit Systems - spectrum of media and reagents	Launched		
	IdioVax - patientspecific idiotypicvaccine for	Phase II		

Company	Products/services	Status	Financial data	Employment data
	the treatment of lymphoma			
Cytonet GmbH & Co.	Liver cell preparation	Development		51 employees
Sygnis	SY300 - neurogenesis of adult stem cells into neurons	Research		
TICEBA GmbH	Skin stem cell bank	Launched		
Number of companies: 4	Number of products services: 6			

Annex D: International comparators

Research activity

- D.1 There is no common source for competitive research funding internationally to draw upon. The international level of analysis is therefore approached differently.
- D.2 In the US, the single largest area of stem cell activity, the National Institute of Health's awards were used to identify the strongest regions in research terms. The remaining regions were identified through discussions with consultees.

Translational activity

- D.3 Translational activity is difficult to measure in the first instance, and it becomes still more difficult when attempting to measure across countries.
- D.4 The US currently has an estimated 1,573 clinical trials involving some aspect of stem cell work. This is a gross figure, not adjusted for research which falls outside the definition used in the UK analysis.
- D.5 The top five regions in the US for stem-cell related clinical trials were:
- California – 370
 - Maryland – 346
 - New York – 338
 - Washington – 288
 - Massachusetts – 231
- D.6 (N.B. a single trial can, and often does, take place in more than one location – on a state by state basis the total number of trials sums to a figure greater than 1,573)
- D.7 There is some correlation between the top performing research regions and clinical trial activity – but the inclusion of Washington and Maryland (both understood to have strong hospital endowments) shows that clinical trials do not necessarily happen in those regions where research is most active. It is worth noting that almost all the American states had some degree of clinical trial activity (although many of these will be participants rather than lead sites), the vast majority in triple or double figures – only Wyoming (7) and Alaska (2) were in single figures.
- D.8 The US clinical trials data also has an element of global coverage, although this is at least in part a record of elements of US-originating trials being carried out in other countries. We are currently exploring the potential of this for assessing progress in other regions outside of the US.

Company base

- D.9 The company base analysis is more straightforward where strong regions can be identified and industry networks exist. We have reviewed Massachusetts, Northern California and Southern California as the strongest regions internationally,.

Table D-1 Company base analysis US regions compared with Scotland

Region	Number of companies	Number of products/services identified	Products/services at research stage	Products/services at development stage	Products/services launched
Massachusetts	14	36	3	12	21
Northern California	8	9	0	7	2
Southern California	9	21	4	8	9
Scotland	4	10	4	1	5

Source: SQW analysis

Table D-2 Company base in Massachusetts

Company	Products/services	Status	Financial data	Employment data
Accelerion	ACE-011 (Bone Growth)	phase 1 trials		
	ACE-031 (Muscle Growth)	pre-Ind		
	ACE-041 (Anti-angiogenesis)	pre-IND		
	Tissue Growth factors	launched		
Advanced Cell Technologies	Myoblasts	Phase II		
	retinal pigment epithelium (RPE) cells	phase I		
	Hemangioblast in vivo testing	development		
Arterioocyte	ACY001 Heart ischemia	Phase I	Grants: \$1.1 million Investment: \$10 million	
	ALO212 for lower limb ischemia	pre-IND		
	ACY001 for Proliferative Diabetic Retinopathy	pre-IND		
	Wound healing	research		
	Tracheal replacement	research		
	Magellan Platelet Rich Plasma concentrator	launched		
	Magellen Cord blood processor	launched		

Company	Products/services	Status	Financial data	Employment data
Etex	Alpha bone substitute materials	launched		
	Beta bone substitute	launched		
	Gamma bone substitute materials	launched		
Genzyme	Epicell for severe burns	launched		
	Carticel: cultured chondriocytes	launched		
	Mozobi (plerixafor) for stem-cell transplantation	phase III/ pre NDa		
Johnson & Johnson Regenerative Therapeutics (Depuy Biologics)				
Novagenesis	Regenerative matrix implants	clinical trial planned for 2008		
Organogeneis	Apligraf: chronic wounds	launched	\$9.5 million Jan 2008	
	VCT101 wound healing late stage development	launched		
	Cuffpatch support material for tendon repair	launched		
	Fortagen: support material for hernia and prolapse	launched		
	Biostar for patent cardiac foramen ovale	launched		
Provasculon	Vascugel material for endothelial support	phase III		
	SDF-1 for attraction of stem cells – cardiovascular disease	research	\$500,000 2007	
Stemgent	Stem cell reagents: multiple laboratory reagents	launched		
TEI Biosciences	Surgimend material for surgery	launched		
	Primatrix: material for wound	launched		
	Durepair: material for neurosurgery	launched		
	Xenform urology	launched		
	Tissuemend: tendon repair	launched		

Company	Products/services	Status	Financial data	Employment data
Viacell	Viacord: cord blood cells	launched	Turnover \$54 million pa (losses \$24 million pa)	
	Viacyte: oocyte preservation	launched		
Wyeth Biotech				1,900 on Andover campus (not all stem cell linked)
Xcellerex				
Number of companies: 14	Number of products/services: 36	Research: 3 Development: 12 Launched: 21		

Table D-3 Company base in Northern California

Company	Products/services	Status	Financial data	Employment data
Acrologix	AC100 for Dental applications	phase II	2006 raised \$30 million Previously raised \$40 million	
	AC100 Orthopaedic applications	phase I		
Beta Stem Therapeutics	Beta cells from stem cells	development		
	Modification of adult haemopoetic stem cells	development		
CarbayIn Biopolymers	polymers for enhanced healing		2007 raised \$20 million	
Izum	Stem cell for regenerative medicine and drug discovery			
Progenitor Cell Therapy				
Stem Cells Inc	Nerve cells	phase I	loss \$6.5 million first quarter 2008	
	Liver regeneration	development		
	Pancreas	development		
Stem Life Services	Frozen in vitro Stem Cells from in vitro fertilised embryos	launched		
Vistagen	Drug discovery using ES cells	launched		
Number of companies: 8	Number of products/services: 9	Research: 0 Development: 7 Launched: 2		

Table D-4 Company base in Southern California				
Company	Products/services	Status	Financial data	Employment data
Advanced Biohealing	Dermagraft: diabetic ulcers	launched	raised \$25 million in 2007	
	Transcyt; full and partial thickness burns	launched		
	Celaderm: venous ulcer treatment	phase 1 trials		
Cytori	Stem Cell Storage	launched	\$800k turnover first quarter 2008 Investment 2008 \$12 million Loss \$8.3 million 1Q 2008-07-24	
	Stem Cell processing	launched		
	Stem Cell Bank	launched		
	Adipose derived stem cells	development		
	Breast reconstruction	pre-IND		
	Myocardial ischemia	phase I		
	Heart attack	phase I		
International Stem Cell Corporation	Replacement Retinal cells	Research		
	Replacement Liver cells	research		
	Diabetes	research		
	Neuronal disease	research		
	Laboratory reagents	launched	Turnover \$38,000	
PrimeCell				
Stemmedica Cell Technologies	Neuronal cells	launched		
Theregen	Anginera Cell based Therapies for heart vascular disease	phase I		
Tissue Repair Company	General Gene Activated Matrix	preclinical		
	Excellerate GAM	phase I/II		
Tulip Biomed	Instruments	launched		
Vetstem	Equine tendons	launched		
Number of	Number of	Research: 4		

Company	Products/services	Status	Financial data	Employment data
companies: 9	products/services: 21	Development:8 Launched: 9		

Japan

- D.10 Japan has a number of hot-spots of research activity – for instance Kyoto University, the Osaka laboratory of the National Institute of Advanced Industrial Science and Technology, the RIKEN Centre for Developmental Biology, Kobe and the Kyoto Frontier Institute , Stem Cell Centre.
- D.11 However, observers consider that the country has relatively poor access to talent and funding at present, with funding only recently starting to flow into the sector, and a lack of interest and appreciation at both government level and among the public. The central government awards £5 million annually for stem cell research on a competitive award basis, and in 2004 60% of this went to RIKEN CDB and Kyoto University, A further £5 million is awarded for more general tissue engineering but this is widely dispersed across different research centres.
- D.12 A new biotechnology strategy was adopted in 2002 due to Japan being considered to have lost ground relative to other leading countries. Weakness in applied biotechnology has been attributed to an alleged weakness in radical innovation although this is not recognised by all – nor supported by the country’s good record in international scientific patents and Nobel prizes. Others argue Japan failed to capitalise on its excellent scientific education, government support and good record of commercialisation because of excessive bureaucratic supervision and inflexibly administered research funding.
- D.13 With high levels of R&D spending (3% of GDP) commentators consider that diminishing returns have set in, with funding used to hire less talented researchers who pursue less promising approaches to the same problems.

China

- D.14 Anecdotal evidence from a 2004 UK study visit¹¹ concluded that Chinese research in stem cells was already world-class, with country's laboratories "are at, or approaching, the forefront of international stem-cell research." However, the country was not yet considered to have the infrastructure to translate its research although it may yet develop new ways to fund and organise its science.
- D.15 Public funding of stem cell research is limited, with the bulk of funding coming through two grant streams from the Ministry of Science and Technology, mostly in the form of two dedicated projects, one for basic stem-cell research and the other for applied stem-cell research. Estimated expenditure of \$12 million between 2000 and 2005. Local governments in Beijing and Shanghai may have matched this amount over the period.

¹¹ Department for Trade and Industry (2006) *Bit Player or Powerhouse? China & Stem Cell Research*

- D.16 United Kingdom Stem Cell Initiative, China's Ministry of Science and Technology plans to devote between \$33 million and \$132 million to stem-cell research during the next 5 years¹².
- D.17 Hot-spots include Beijing University's Stem-Cell Research Center the Institute of Zoology at the Chinese Academy of Sciences, Beijing; Xinhua Hospital in Shanghai; and Xiangya Medical College in Changsha.
- D.18 There are an estimated 300 to 400 researchers with Ph.D.s are working on all types of stem cells. The pool of lower-level researchers is limited, however, and promising students, like the leaders of their laboratories, go abroad for advanced training. At this stage, therefore, the pipeline of scientific talent in China is small.
- D.19 Chinese stem cell researchers are considered to be more focused on moving the science into the clinic than on understanding the basic mechanisms of stem cell biology, with scientists and clinicians eager to pursue clinical trials of cell-based therapies and several such trials are now under way to treat brain injury, corneal disease and neurodegenerative illness. This effort has also given rise to a number of spin-out companies, although these continue to be mostly state funded, rather than raising funding from private sources.
- D.20 However, China is considered to have a cost advantage and if this can be matched with technical skills it could become a force in producing standardised elements such as cloned laboratory animals and equipment for stem-cell manipulation.

South Korea

- D.21 The reputation of South Korea, as a world leader in stem cell research was tarnished in 2005 by Hwang Woo Suk, who claimed to have cloned the first human embryo, was later exposed as a fraud.
- D.22 Despite this reputational set-back, it is reported¹³ that stem cell science in Korea is bouncing back with better focus and balance. First, the Korean government has been reassuring by vowing to continue to support stem cell research in Korea, with a long-term spending plan of \$454 million over the next 10 years. This represents an even higher level of funding than pre-Hwang scandal. Funding will now be diversified, rather than focused on a single star scientist.
- D.23 Nongovernment sectors are also advancing their stem cell plans. CHA medical group recently announced plans to build a new CHA Stem Cell Institute in Pangyo Techno Valley on the outskirts of Seoul, with a floor space of 66,200 m², due to open in 2010. This institute will include a Lab-to-Patient system with a Good Manufacturing Practice grade facility.
- D.24 South Korean advanced in stem cell research are considered to be due in part to very flexible policies regarding research, including progress in therapeutic cloning means they can efficiently produce stem cells tailored to the individual and with a low risk of immunological rejection¹⁴. In March 2007, South Korea's national bioethics committee agreed partially to lift

¹² <http://content.nejm.org/cgi/content/full/355/12/1191>

¹³ <http://stemcells.alphamedpress.org/cgi/content/full/25/5/1336>

¹⁴ <http://www.explorestemcells.co.uk/StemCellResearchAroundWorld.html>

a ban on human embryonic stem cell cloning research, imposed after the Hwang scandal, and allow local scientists to resume their research¹⁵.

- D.25 A company base is developing in South Korea, for instance BHK Inc¹⁶ joined the Alternative Investment Market in London in 2008, and currently has a market capitalisation of \$80 million.

¹⁵ <http://www.ft.com/cms/s/0/6c394b70-e892-11db-b2c3-000b5df10621.html>

¹⁶ BHK is the Asian licensee for MyoCell, a stem cell-based treatment for heart disease developed by Bioheart of Florida and currently in Phase II clinical trials.

Annex E: Existing Economic Impact Assessments

- E.1 Two of the projects under the Stem Cell Intervention Framework, the Scottish Stem Cell Network (SSCN) and the Scottish Centre for Regenerative Medicine have had economic impact assessment¹⁷ carried out as part of the application process to Scottish Enterprise for funding. These EIAs forecast quite ambitious levels of economic activity, especially in regard to licensing activity and the creation of spin-out companies.
- E.2 While this study cannot revisit the Economic Impact Assessments, based on our own understanding of the sector developed through consultations and discussions, we would anticipate a lower level of activity from these projects in the near term, and in the case of the SSCN, qualitatively different achievements – i.e. animation and representation rather than licensing or company creation.
- E.3 The EIAs were written two to three years ago, and therefore lacked current knowledge of the difficulties of translating and commercialising stem cell research. The writers were forced to rely on estimates derived from more general academic activity and from the more mature biotechnology industry.
- E.4 However, the EIAs have formed part of the application process to SE and funding has been secured on the basis of the EIA targets. The progressions suggested by the EIAs do represent alternative interpretations of the potential of these projects. We would therefore recommend that the SSCN and SRCN project personnel continue to track their achievement against the metrics suggested by the EIA.

Table E-1: Scottish Stem Cell Network - Proposed monitoring and evaluation framework

Rationale	Inputs	Activities	Intended outputs	Intended outcomes	Intended impacts
Market failure – Imperfect information	£1.75 million (Scottish Enterprise)	Delivery of workshops	3,450 annual attendees to day events	SSCN to become self-supporting over period	Increased employment and GVA through commercial stem cell activity
The SSCN seeks to correct the information deficiency associated with an emergent field through consolidation, protection, enhancement and promotion of stem cell science and technology development in Scotland.	£1.75 million (private sector contributions)	Hosting an annual international conference	4,400 attendees to international conference	Increased interactions within Scottish stem cell community and with organisations and networks outside	Direct impact - £247,068 and 6.4 jobs
		Attending overseas events per year	81 collaborative research projects		Business tourism impact - £58,610 and 4.4 jobs;
		Attending non-SSCN national events per year	24 licenses generated		Collaborative project impact - £1,335,000 and 19.2 jobs;
		SSCN delivering 1 public outreach activity per year	8 company start-ups		Licensing impact – £5,021,302 and 114.6 jobs;
		Hosting/assisting with inward investment visits	5 inward companies		Spin/start-ups – £5,409,509 and
		Supporting** Scottish	75 academics attracted		

¹⁷ Biggar Economics (2005) Scottish Stem Cell Network (Phase 2) – Economic Impact Assessment

Rationale	Inputs	Activities	Intended outputs	Intended outcomes	Intended impacts
		Enterprise with at least 1 major infrastructure project (e.g. GLP)			174.6 jobs;
		SSCN supporting** Scottish Enterprise with at least 1 major collaborative project (e.g. UKSCF)			Inward investment - £1,358,577 and 30.3 jobs; and
		SSCN delivering 4 newsletters per year			Additional academics - £1,109,475 and 53.3 jobs
		Website			
		Networking activity with UK, European and international networks			
		SSCN selling membership to all major players in the Scottish stem cell sector within 10 years			
		Registration and membership activity			

Source: Biggar Economics/SQW presentation

- 8.16 Projected achievements for the SCRM exist for each year from 2006 to 2015, We would suggest reviewing these by 2011 or sooner to re-assess their realism.

Table E-2: Scottish Centre for Regenerative Medicine – proposed monitoring and evaluation framework

Rationale	Inputs	Activities	Intended outputs	Intermediate outcomes	Intermediate impacts
Market failure – Imperfect information	£59 million	Consolidation and expansion of Edinburgh University's existing research groups.	Facilities for 150 researchers.	Retention/attract ion of leading researchers.	Investment by private sector.
Translation of research into commercial opportunities is vital to success, however a funding gap at this stage exists as significant resources are needed but venture capitalists will not invest because of the high risks, pharma companies		Creation of a centre for 'scale-up' development and manufacturing of cells to a GMP standard.	150 researchers recruited.	Improved collaboration between research and company base.	Number of discoveries entering pre-clinical phase.
		Space to accommodate commercial stem cell research organisations and spin-outs.	900 metres of space for scale-up/GMP manufacturing.	Increased investment attracted.	100 %occupancy of premises by private companies by 2011.
			675 square metres of premises for commercial firms.	New products and services developed from Scottish research.	5 lines of research licensed by 2011
					3 spinout companies created by 2011.

Rationale	Inputs	Activities	Intended outputs	Intermediate outcomes	Intermediate impacts
					57 FTE employment in spin-out companies by 2011 Net GVA (Scottish level) by 2011

Source: SQW (drawing on Biggar Economics Scottish Centre for Regenerative Medicine Economic Impact Assessment)