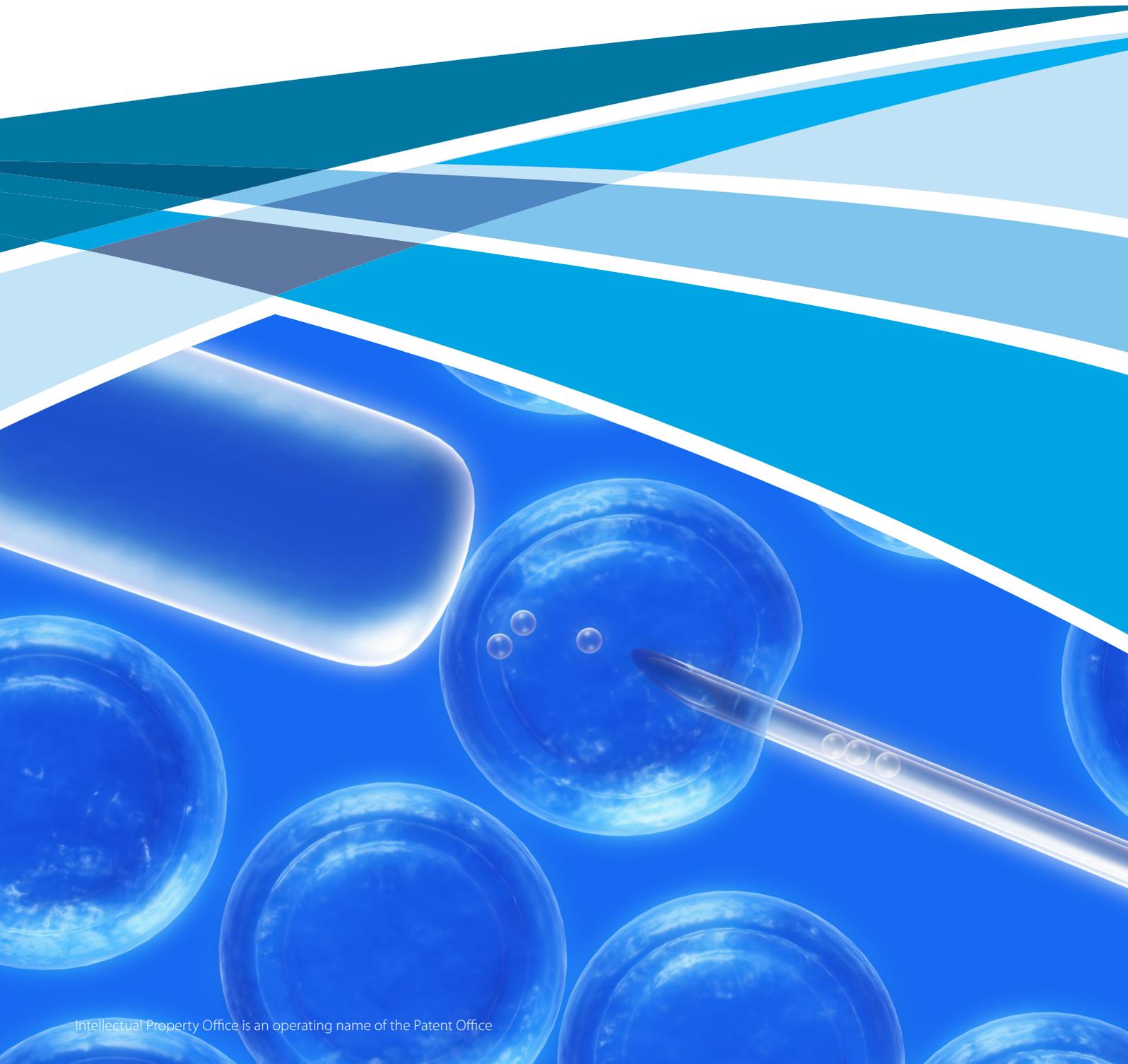




**INTELLECTUAL**  
PROPERTY OFFICE

# Stem Cells

## UKNSCN patent watch landscape



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## Executive Summary

The UK National Stem Cell Network (UKNSCN) provided the stem cell community with regular digests of both published and granted patents in the field of stem cells. The patent watch reports were provided by the Intellectual Property Office every two months between 1 November 2008 and 31 October 2011.

In April 2010 a report giving an overview of the first year of stem cell patent digests (1 November 2008 to 31 October 2009) was produced by the Patent Informatics Team at the Intellectual Property Office. This report provides an update on this initial patent landscape overview and analyses the patents published and granted during the period from 1 November 2008 to 31 October 2011, with a detailed focus on the current patent landscape and the changes in stem cell patenting over the last two years.

Corporations and academia account for over 85% of both published patent applications and granted stem cell patents, with corporations having a marginally higher market share. Despite the corporate sector having the majority market share, the top applicant of published patent applications is Kyoto University in Japan and the top applicant of granted patents is Wisconsin Alumni Research Foundation in the USA. The University of Edinburgh is the top UK applicant of both published patent applications and granted stem cell patents. Analysis of the patent classifications applied to the published patent applications suggests that recent research is focused on mesenchymal stem cells, pluripotent cells (e.g. embryonic stem cells) and artificially induced pluripotent cells (e.g. iPS). The top three areas for granted stem cells patents are pluripotent cells (e.g. embryonic stem cells), haematopoietic stem cells/uncommitted or multipotent progenitors, and stem cells/progenitor cells/precursor cells of the nervous system.

In the broader fields of neurological and ophthalmic patenting, the corporate sector has the majority of both published patent applications and granted patents. In the antineoplastic area, both the corporate and academic sectors have a similar market share of both published and granted patents. Academia holds the majority market share for published cardiovascular patent applications, but this is reversed for granted cardiovascular patents with corporations having the majority of the market share.

The UKNSCN patent watch dataset is limited to patent applications published having WO, US, EP and GB designations, along with the granted US, EP and GB patents; hence, in order to place the results of the UK patent watch in a more global context and to give a fuller picture of the worldwide activity in relation to stem cells, an overview of the complete global dataset would be beneficial especially given the recent rise in worldwide patent filings from countries such as China and India.

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# 1 Introduction

The UK National Stem Cell Network (UKNSCN) provided the stem cell community with regular digests of both published and granted patents in the field of stem cells<sup>1</sup>. The patent watch reports were provided by the Intellectual Property Office every two months between 1 November 2008 and 31 October 2011.

In April 2010 a report giving an overview of the first year of stem cell patent digests (1 November 2008 to 31 October 2009) was produced by the Patent Informatics Team at the Intellectual Property Office<sup>2</sup>. This report provides an update on this initial patent landscape overview and analyses the patents published and granted during the period from 1 November 2008 to 31 October 2011, with a detailed focus on the current patent landscape and the changes in stem cell patenting over the last two years.

In order to provide a macroscopic overview of the dataset provided to the UKNSCN, this report analyses the patent data by considering the following areas:

- **Historical filing profile**
- **Invention origin**
- **Top applicants**
- **Breakdown by sector (corporate, academic, government etc)**
- **Collaboration**
- **Breakdown by patent classification**
- **Breakdown by stem cell technology area**
- **Patent landscape map analysis**

1 [http://www.uknscn.org/downloads/patent\\_digests.html](http://www.uknscn.org/downloads/patent_digests.html)

2 [http://www.uknscn.org/downloads/patent\\_analysis\\_0811.pdf](http://www.uknscn.org/downloads/patent_analysis_0811.pdf)

## 2 Patent analysis

### 2.1 Dataset summary

The complete UKNSCN patent digests from 1 November 2008 to 31 October 2011 were fused together to provide the dataset used for this report. The UKNSCN patent digests contain details of the search strategy used, but an exemplar search strategy is shown in Appendix A. Table 1 shows a summary of the published patent applications and granted patents in the stem cell dataset.

The dataset is limited to patent applications published having WO, US, EP and GB designations, along with the granted US, EP and GB patents. It should be noted that WO patent applications are those filed using the international Patent Cooperation Treaty (PCT) route; these patent applications lead to national or regional applications at the relevant national offices, hence there will be no granted WO patents.

		Published patents		Granted patents	
<b>Number of patent publications</b>		3134		777	
<b>Number of patent families</b>		2499		725	
<b>Publication date range</b>		1 November 2008 - 31 October 2011		1 November 2008 - 31 October 2011	
<b>Top applicant</b>		Kyoto University (Japan)		Wisconsin Alumni Research Foundation (USA)	
<b>Field choices</b>	<b>Field Name</b>	<b>Number of entries</b>	<b>Coverage</b>	<b>Number of entries</b>	<b>Coverage</b>
<b>People</b>	Inventors	5647	99%	1677	99%
<b>Applicants</b>	Patent assignees	1210	80%	482	92%
<b>Countries</b>	Priority Countries	33	100%	21	100%
<b>Years</b>	Priority Year	19	100%	18	100%
<b>Technology</b>	IPC (Advanced)	1015	99%	531	100%

Table 1: Dataset summary

## 2.2 Historical filing profile

Figure 1 shows the number of published patent applications by earliest priority date. Figure 2 shows a similar chart for the granted stem cell patents, and Figure 3 provides a comparison between the published and granted patents. It is more relevant to look at the priority date instead of the filing (application) date because this gives a better indication as to when the research work relating to the patent applications was being undertaken.

A patent is normally published 18 months after the priority date or the filing date (whichever is earlier)<sup>3</sup>, hence the 2010 and 2011 data is incomplete and explains the 'drop-off' in Figure 1 since 2009; the 'drop-off' for granted patents in Figure 2 is even earlier due to patent pendency times, with patents granted in 2011 most likely to have a priority date between 2005 and 2007.

Although the dataset only contains patents published or granted between November 2008 and October 2011, the earliest priority date goes back to 1989 (US 2008/0305074 A1, published on 11 December 2008, has an earliest priority date of 16 October 1989). A small number of both published and granted patents have priority dates in the 1990s and early- to mid-2000s. One reason for this is the 'continuation-in-part' procedure in the USA which allows for a patent application to potentially continually claim priority from earlier applications. This trend is seen in both the published and granted data shown in Figure 1 and Figure 2.

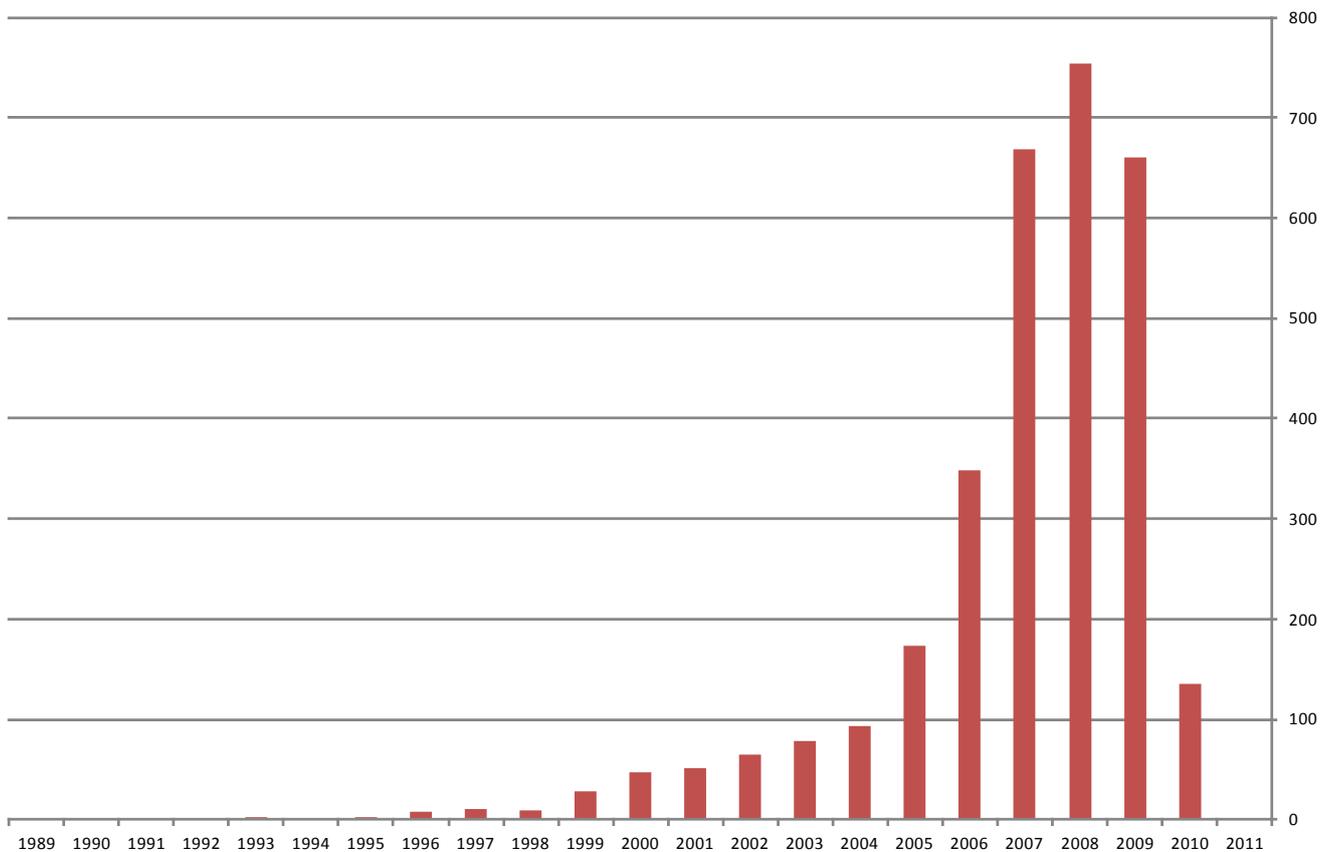


Figure 1: Published patent applications by priority year

3 See Appendix A.1 for a full explanation of the difference between priority dates, application dates and publication dates

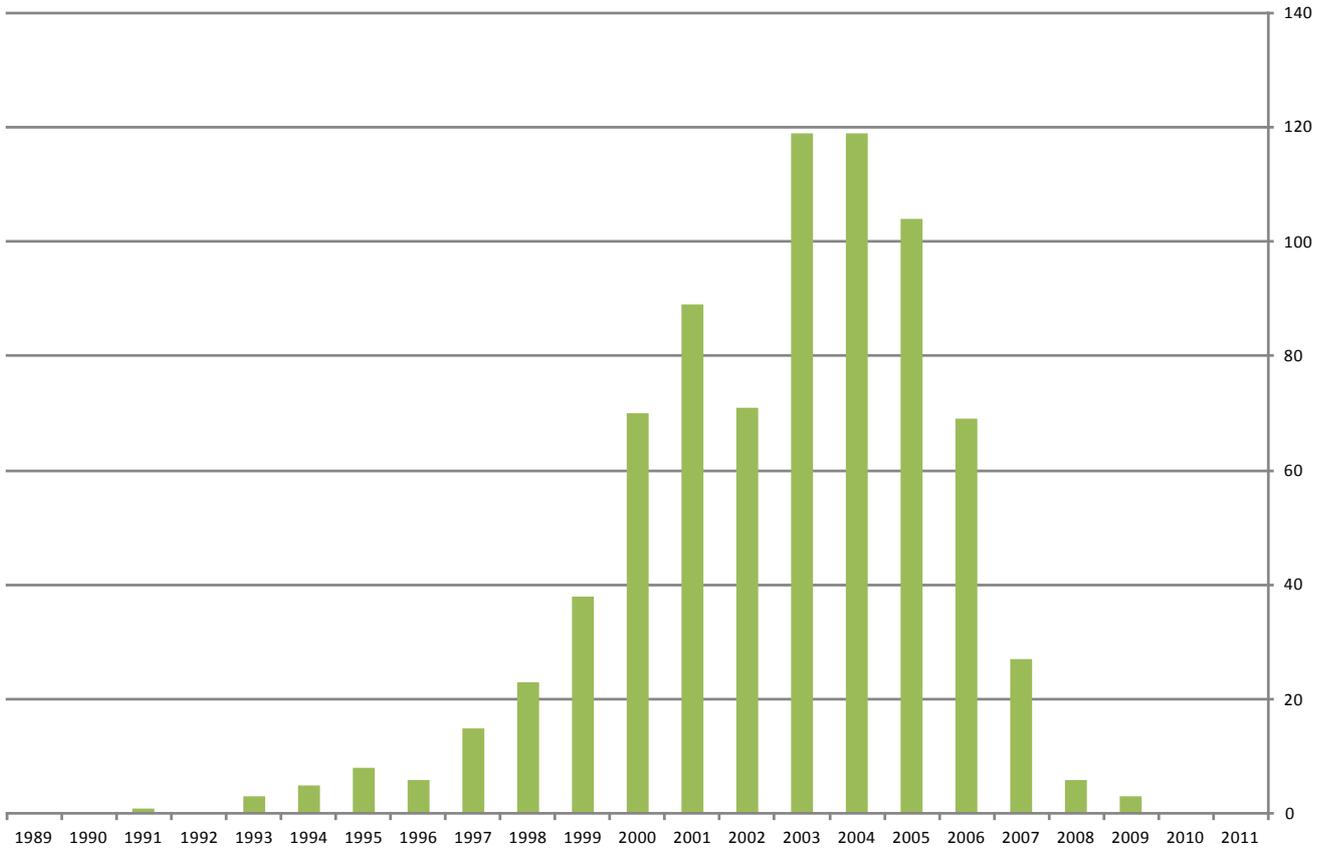


Figure 2: Granted patents by priority year

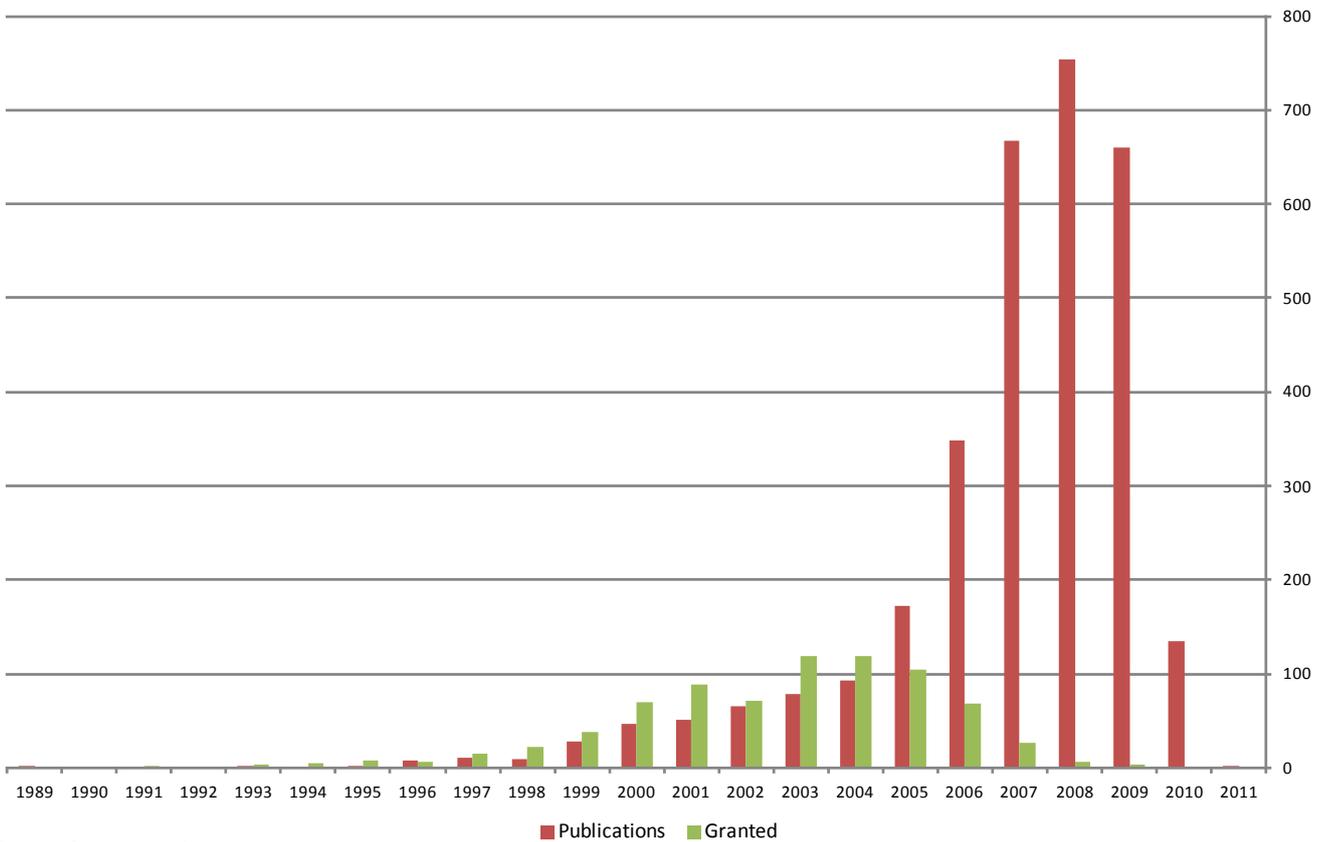


Figure 3: Comparison of published patent applications and granted patents by priority year

## 2.3 Invention origin

Analysis of the priority country gives a good indication of where in the world the research and development is taking place because most applicants will first file for a patent application in the country in which the research work is been undertaken.

Figure 4 and Figure 5 show the top priority countries for the published patent applications and granted patents within the dataset. Different colours have been used to highlight the change in the patent landscape in the 12 months between November 2008 and October 2009 and the 24 months between November 2009 and October 2011; for example, Figure 4 shows 497 patents with a US priority were published between November 2008 and October 2009 compared to 1686 patents published between November 2009 and October 2011 (a total of 2183 patents published with a US priority in the dataset).

Given that the dataset is limited to WO, US, EP and GB patent publications, it is not surprising that the US and WO patents dominate these two charts.

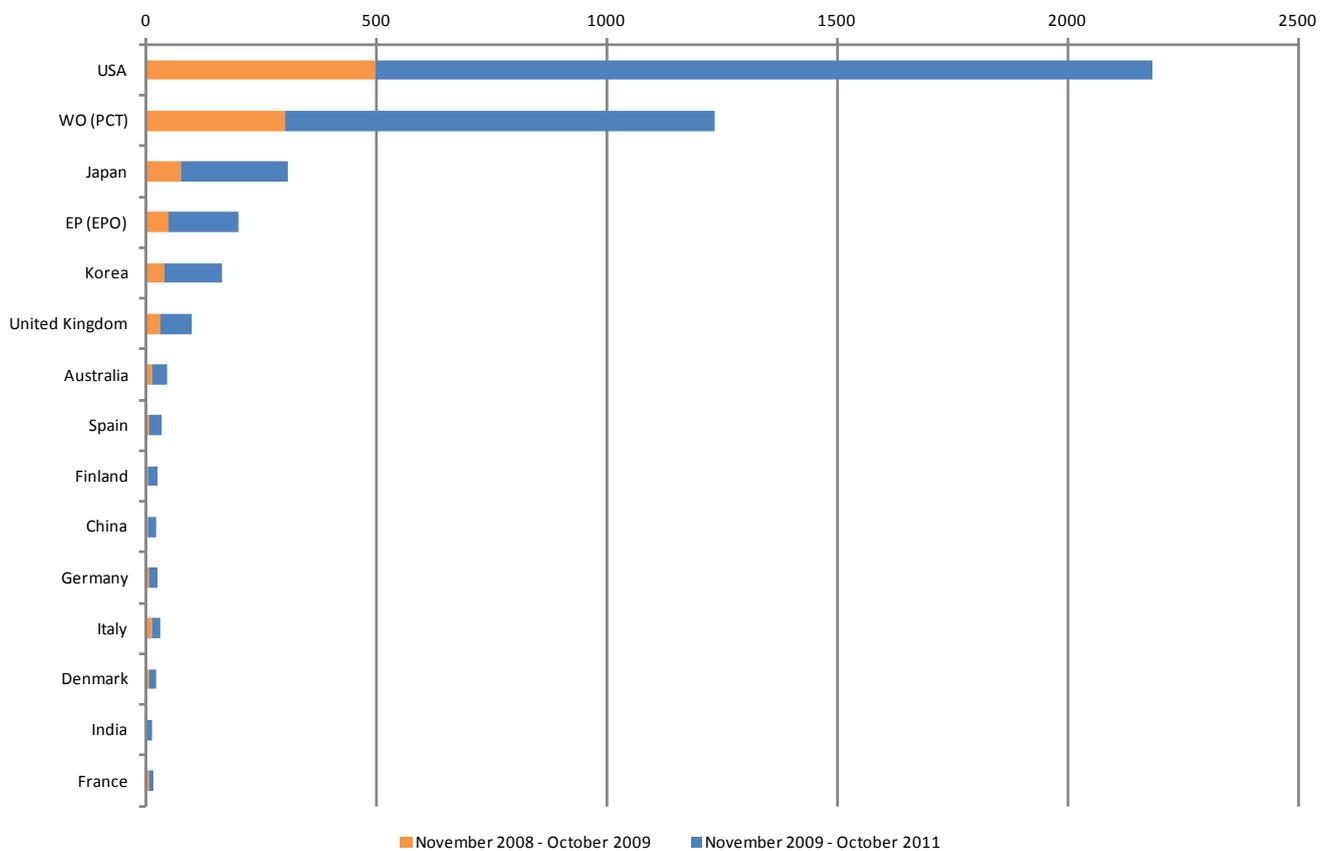


Figure 4: Top priority countries of published patent applications

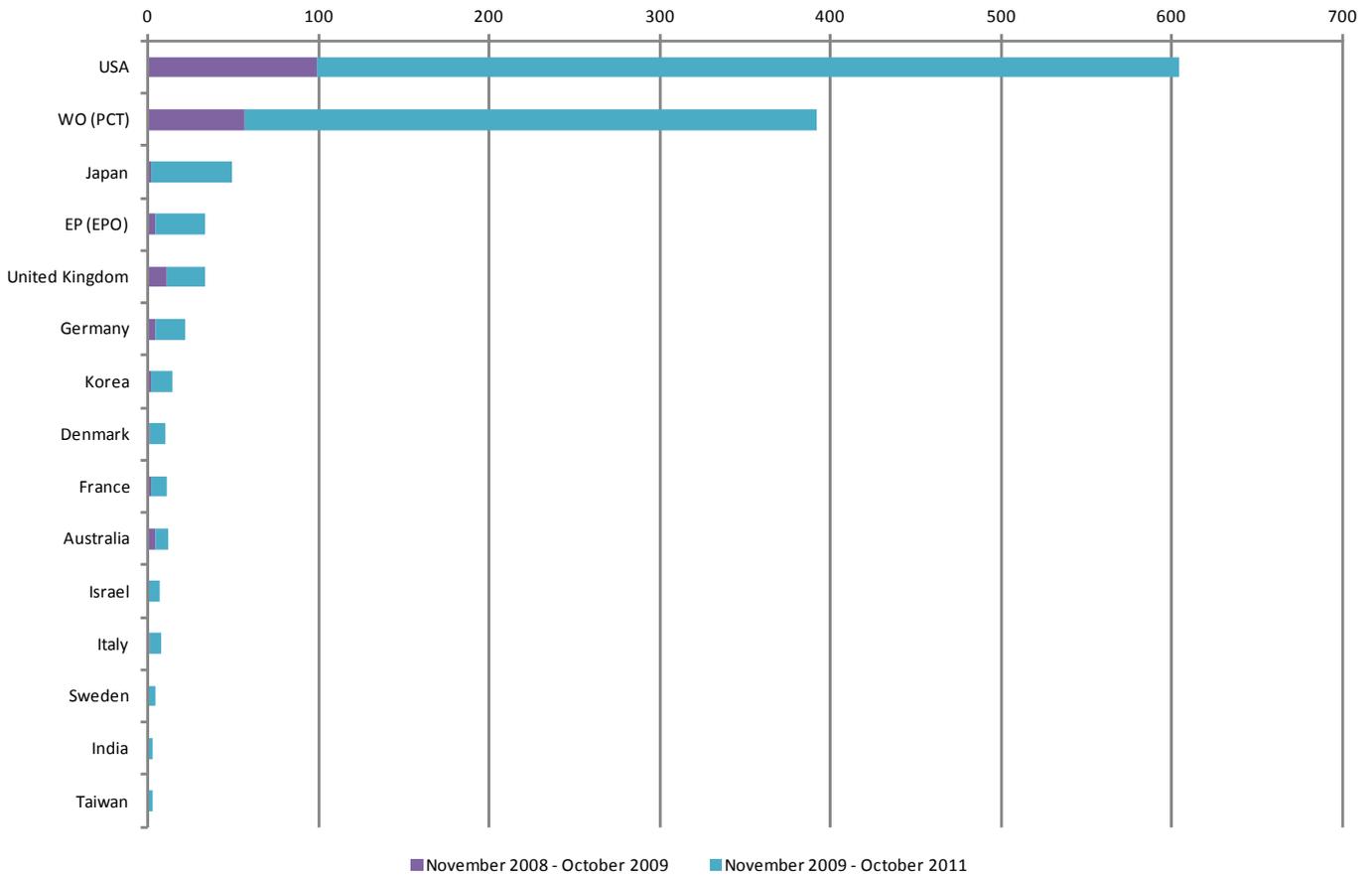


Figure 5: Top priority countries of granted patents

## 2.4 Top applicants

Figure 6 and Figure 7 show the top applicants for the published patent applications and granted patents within the dataset. It is interesting to note the number of universities and other academic institutions within the top applicants in both charts which is in contrast to the ‘corporate domination’ usually seen during macroscopic patent analysis of many technology areas; this is most likely due to the fact that stem cells is such a specialised and research-focused area of technology.

Kyoto University in Japan is the top applicant within the published patent data and Wisconsin Alumni Research Foundation in the USA is the top applicant within the granted patent data; these are the same top applicants seen in the original patent landscape report produced in April 2010.

Again, different colours have been used to highlight the change in the patent landscape in the 12 months between November 2008 and October 2009 and the 24 months between November 2009 and October 2011. It is interesting to note that all of the top applicants with published patent applications shown in Figure 6 had applications in both time periods (November 2008 to October 2009 and November 2009 to October 2011) whereas Figure 7 shows that several of the top applicants of granted patents did not have any granted patents before November 2009.

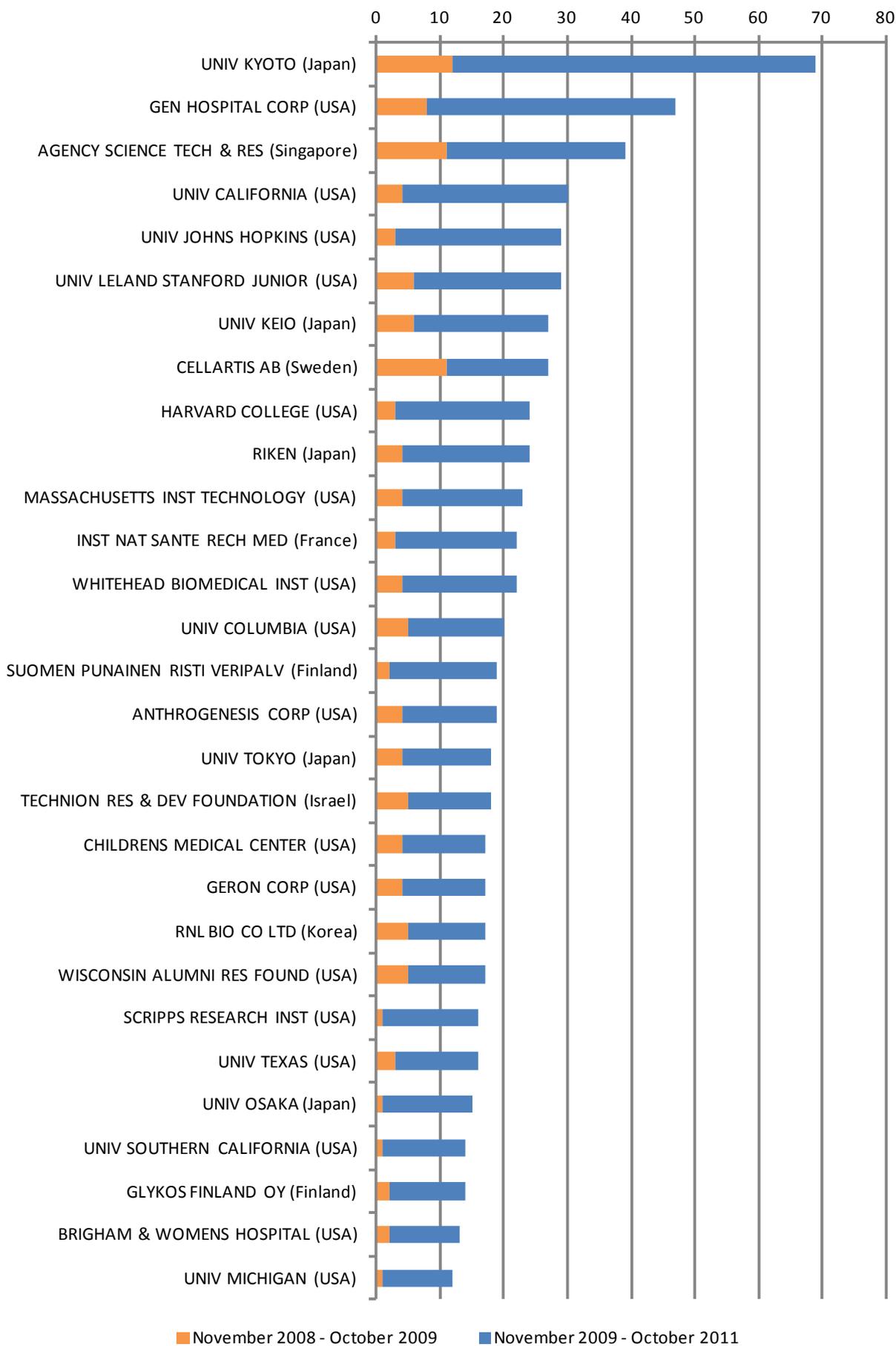


Figure 6: Top applicants of published patent applications

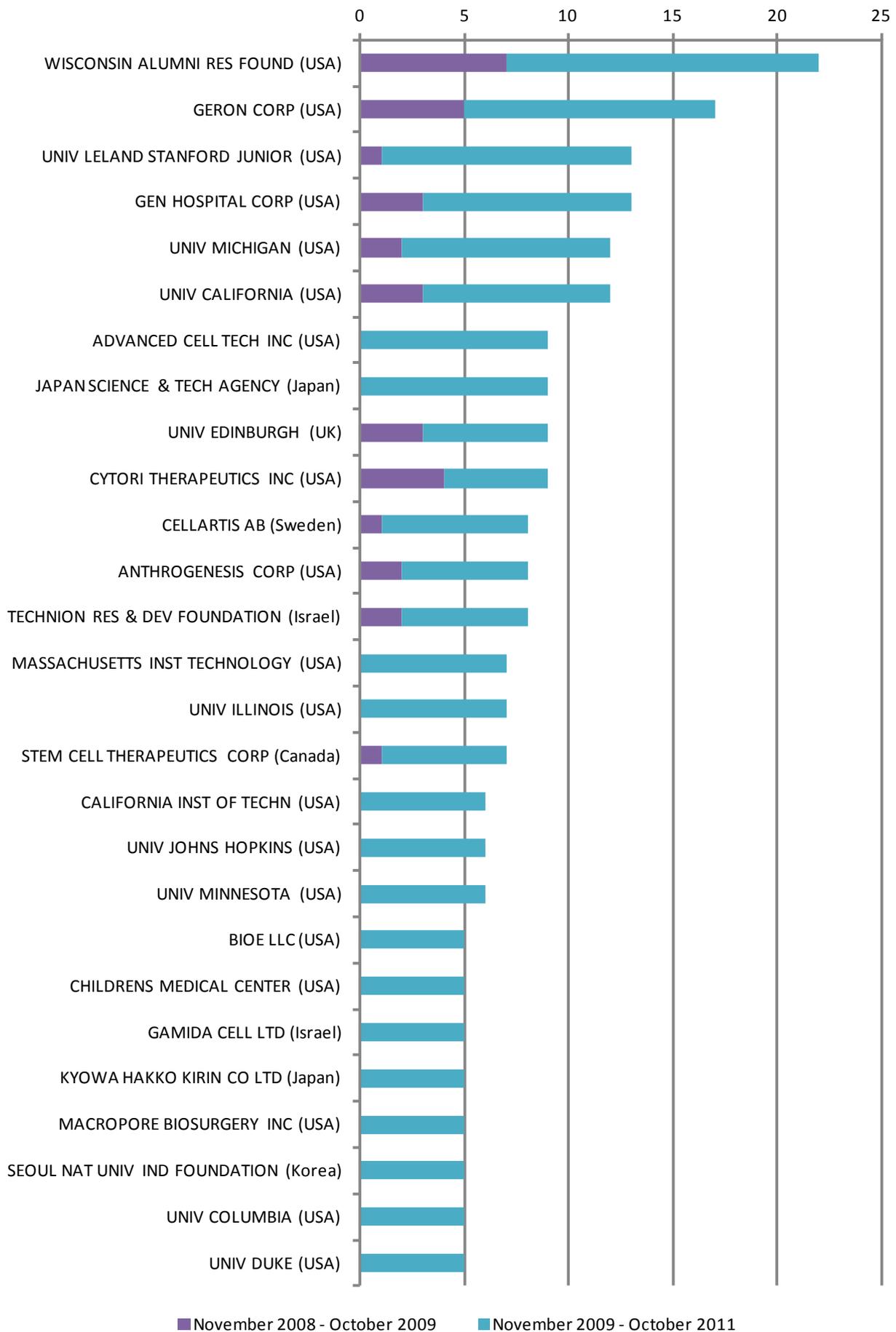


Figure 7: Top applicants of granted patents

It is interesting to compare the similarities between the priority country distributions shown in Figure 4 and Figure 5 and the applicant country distribution shown in Figure 8. Obviously WO and EP data will appear in Figure 4 and Figure 5 and not Figure 8, but the ranking and distribution of the 'actual' countries follows a similar trend in both figures as expected.

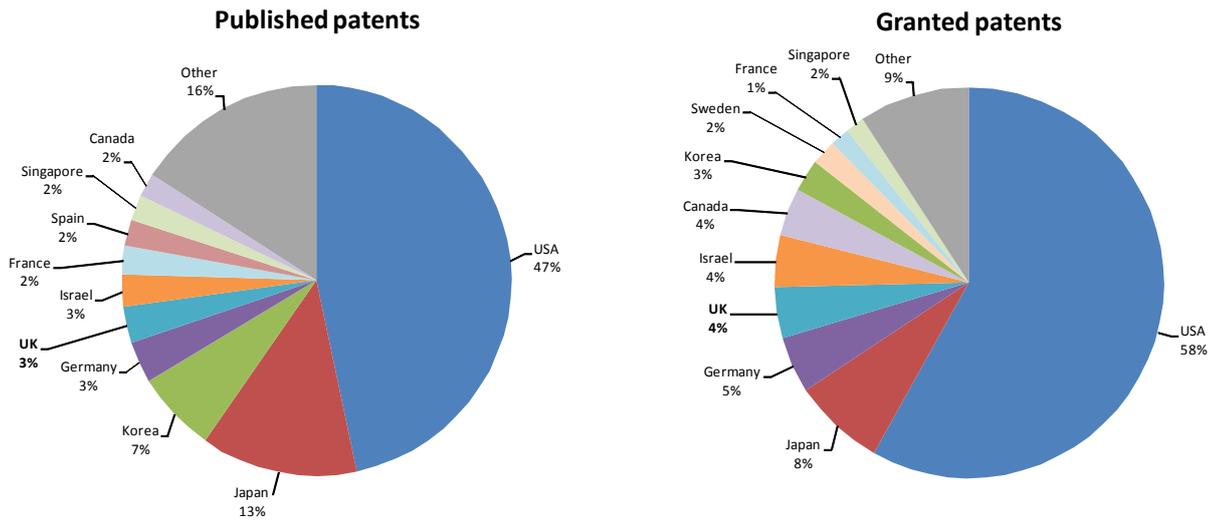


Figure 8: Applicant country distribution across dataset

However, it is well known that there is a greater propensity to patent in certain countries than others, and the trends shown in Figure 8 may change if the figures are corrected for this difference in behaviour. Therefore, the Relative Specialisation Index (RSI)<sup>4</sup> for each applicant country within the published patent application dataset has been calculated to give an indication of the level of invention in stem cells for each country compared to the overall level of invention in that country, and this is shown in Figure 9.

The RSI shown in Figure 9 appears to suggest a very different picture to that shown in Figure 8. The USA, Japan, Korea and Germany are the top four applicant countries and appear relatively specialised in the field of stem cells, but this is now reversed when the RSI is applied as these countries rank below several others including Singapore, Israel and Australia. These three high-ranking countries, especially Singapore, show much greater levels of patenting in stem cells than expected, despite their modest absolute levels of patenting. Published patents by UK applicants are around the level expected, given the mildly negative value of RSI at -0.11.

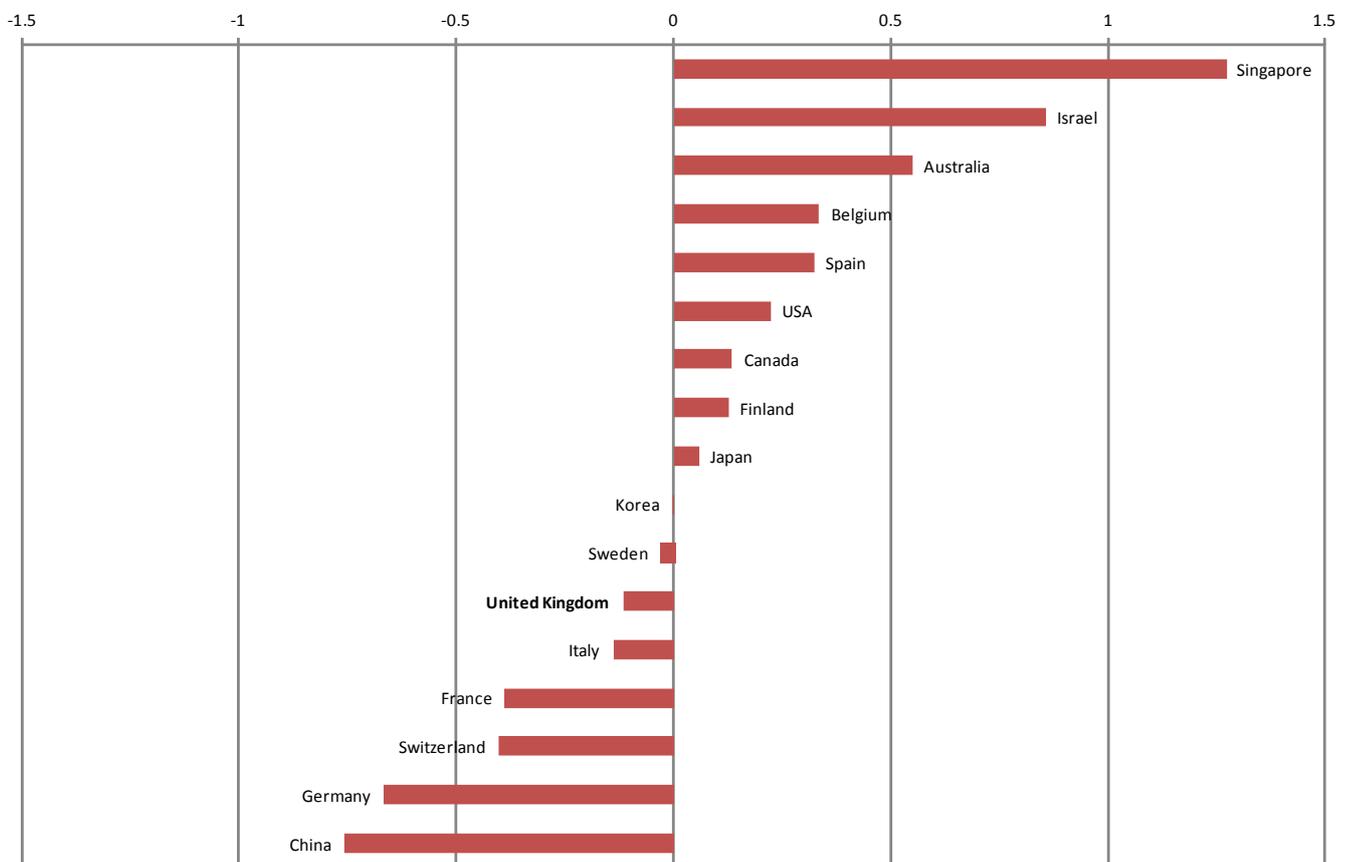


Figure 9: Relative Specialisation Index (RSI) by applicant country for published patent applications

<sup>4</sup> See Appendix B for full details on how the Relative Specialisation Index is calculated

Table 2 shows the top UK applicants for both published patent applications and granted patents. As in the April 2010 report, the University of Edinburgh is the top UK applicant in terms of both published patent applications and granted patents. The University of Edinburgh is also closely affiliated with the Roslin Institute, an animal sciences research institute based in Edinburgh.

	Published patents	Granted patents	Total
UNIV EDINBURGH	10	8	<b>18</b>
CAMBRIDGE ENTPR LTD	10	1	<b>11</b>
ITI SCOTLAND LTD	4	1	<b>5</b>
UCL BUSINESS PLC	4	0	<b>4</b>
GERON CORP	3	1	<b>4</b>
ISIS INNOVATION (UNIV OXFORD)	1	3	<b>4</b>
ANTOXIS LTD	3	0	<b>3</b>
BIOCOMPATIBLES UK LTD	3	0	<b>3</b>
STEM CELL SCIENCES	3	0	<b>3</b>
UNIV CARDIFF	3	0	<b>3</b>
UNIV GLASGOW	3	0	<b>3</b>
UNIV SHEFFIELD	3	0	<b>3</b>
ROSLIN INST	2	1	<b>3</b>

Table 2: Top UK applicants

## 2.5 Sector breakdown

Figure 10 and Figure 11 shows the sector breakdown for all applicants within the published patent applications and granted patents data. In order to provide a breakdown of the types of applicants applying for or holding stem cell related patents, the applicants were categorised as corporate, academic, hospital, government or individuals. For this report the 'academic' category includes universities, research foundations and other institutions. The category 'individuals' was used where no obvious link to an organisation could be found; these patents may legitimately be patents applied for by individual people or the assignment to an organisation may not have yet been entered onto the patent databases through statutory-related delays in certain jurisdictions.

Three pie charts are used in each figure; one for the sector breakdown for the November 2008 to October 2009 data, one for the November 2009 to October 2011 data, and one for the combined data (i.e. November 2008 to October 2011).

Figure 10 and Figure 11 show that stem cell patenting is dominated by the corporate and academic sectors, which is perhaps a reflection on the type of research and funding that is required in this area of technology. The higher-than-usual market share from academic applicants is not surprising given the number of universities in the top applicants in Figure 6 and Figure 7.

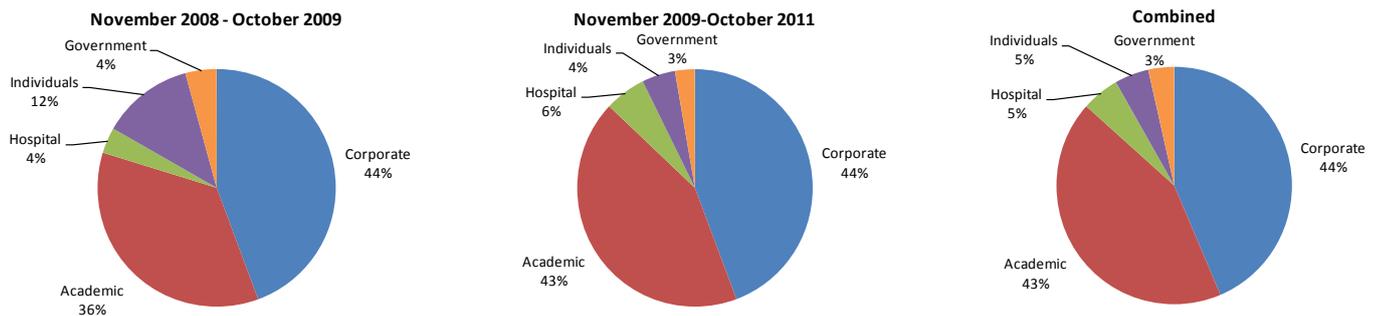


Figure 10: Sector breakdown of published patent applications

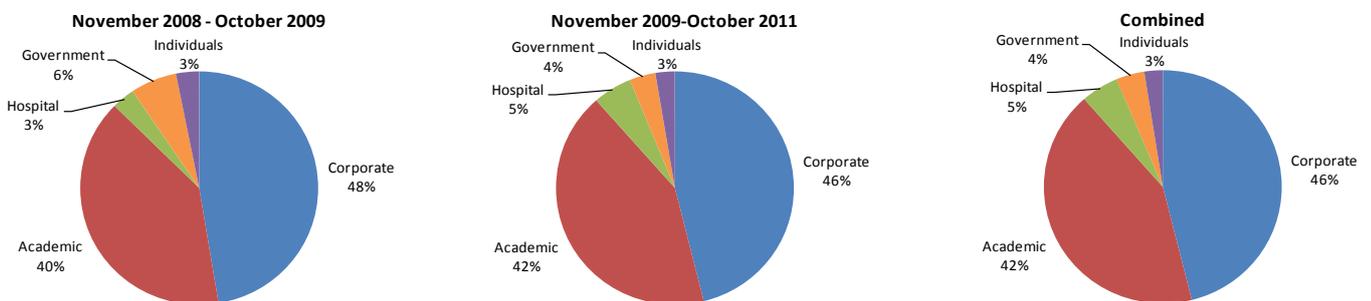


Figure 11: Sector breakdown of granted patents

Figure 12 and Figure 13 show a breakdown of the different applicant types by earliest priority date.

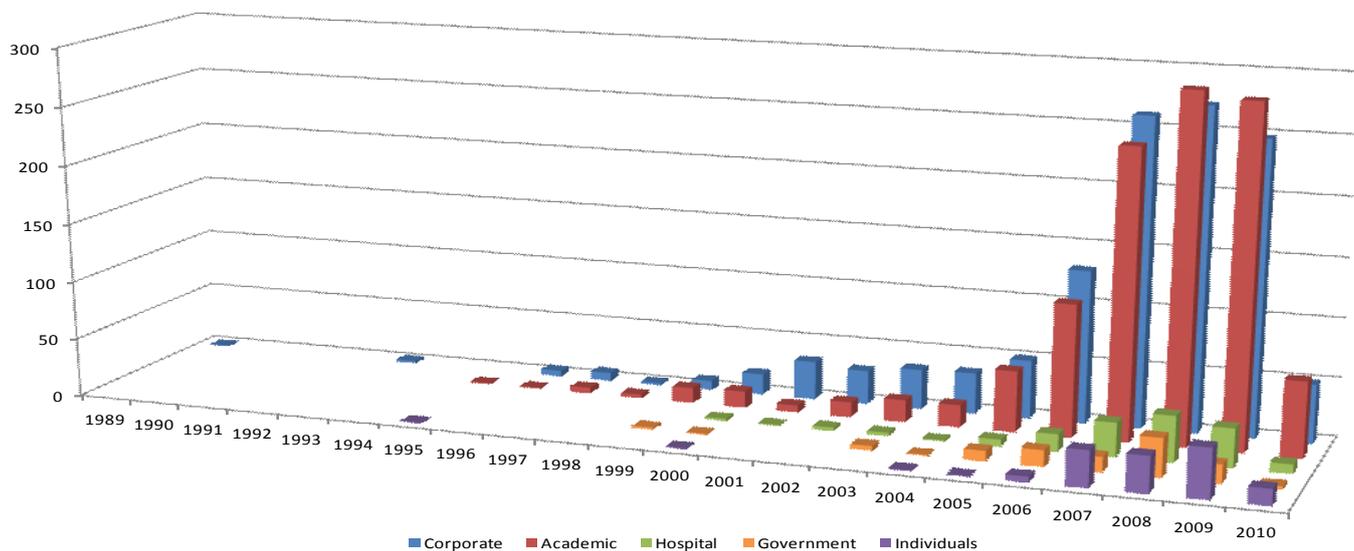


Figure 12: Applicant type by priority year of published patent applications

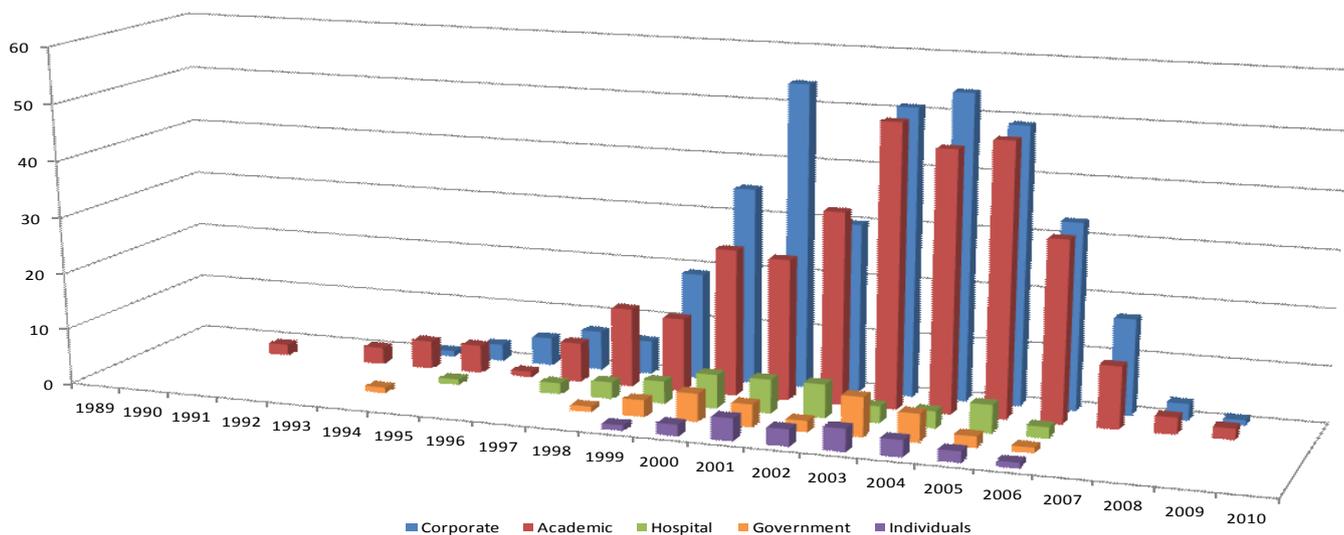


Figure 13: Applicant type by priority year of granted patents

## 2.6 Collaboration

The top filing applicants in both datasets were analysed and the resultant collaborations were plotted on a map. Each of the top applicants is plotted along with any of their collaborators (i.e. not just the top applicants) and each patent is represented by a dot.

Figure 14 shows the collaborations between the applicants who have published the most patents and Figure 15 shows the collaborations between those who have the most granted patents. The top filer, Kyoto University, is shown in the top left of Figure 14 and, in addition to a healthy portfolio of patents solely in their own name, they have also collaborated on patents with other Japanese universities (e.g. Gifu University and Tohoku University), Japanese institutions (e.g. Stem Cell and Drug Discovery Institution in Kyoto) and both Japanese and international corporations (e.g. Oriental Yeast in Japan, and iPierian, who are based in San Francisco, USA).

The other major collaboration 'web' in the top right of Figure 14 revolves around Central Hospital Corporation who do business as Massachusetts General Hospital (MGH). MGH is the third-oldest and one of the biggest hospitals in the USA<sup>5</sup> and serves as the major non-profit teaching hospital of Harvard College; this explains the close links and collaboration between these two organisations. MGH have no international collaborators but have collaborated domestically in the USA with Massachusetts Institute of Technology (MIT), the University of North Carolina, the Children's Medical Center of Dallas, the Immune Disease Institute and the Dana-Farber Cancer Institute (both based in Boston), and Maryland biotechnology company Viacell.

The top UK applicant, the University of Edinburgh, has collaborated on one published patent application (US 2010/086999 A1, published 8 April 2010), entitled "Differentiation of primate pluripotent cells to hepatocyte-lineage cells", with Geron Corporation (a biotechnology company based in California, USA).

Figure 14 shows that all but one of the top applicants shown in Figure 6 have had at least one published patent application with at least one collaborator, whereas Figure 15 shows that five of the top applicants shown in Figure 7 have no collaborators (the five isolated 'blobs' located near the bottom left of the map).

5 <http://www.massgeneral.org/>



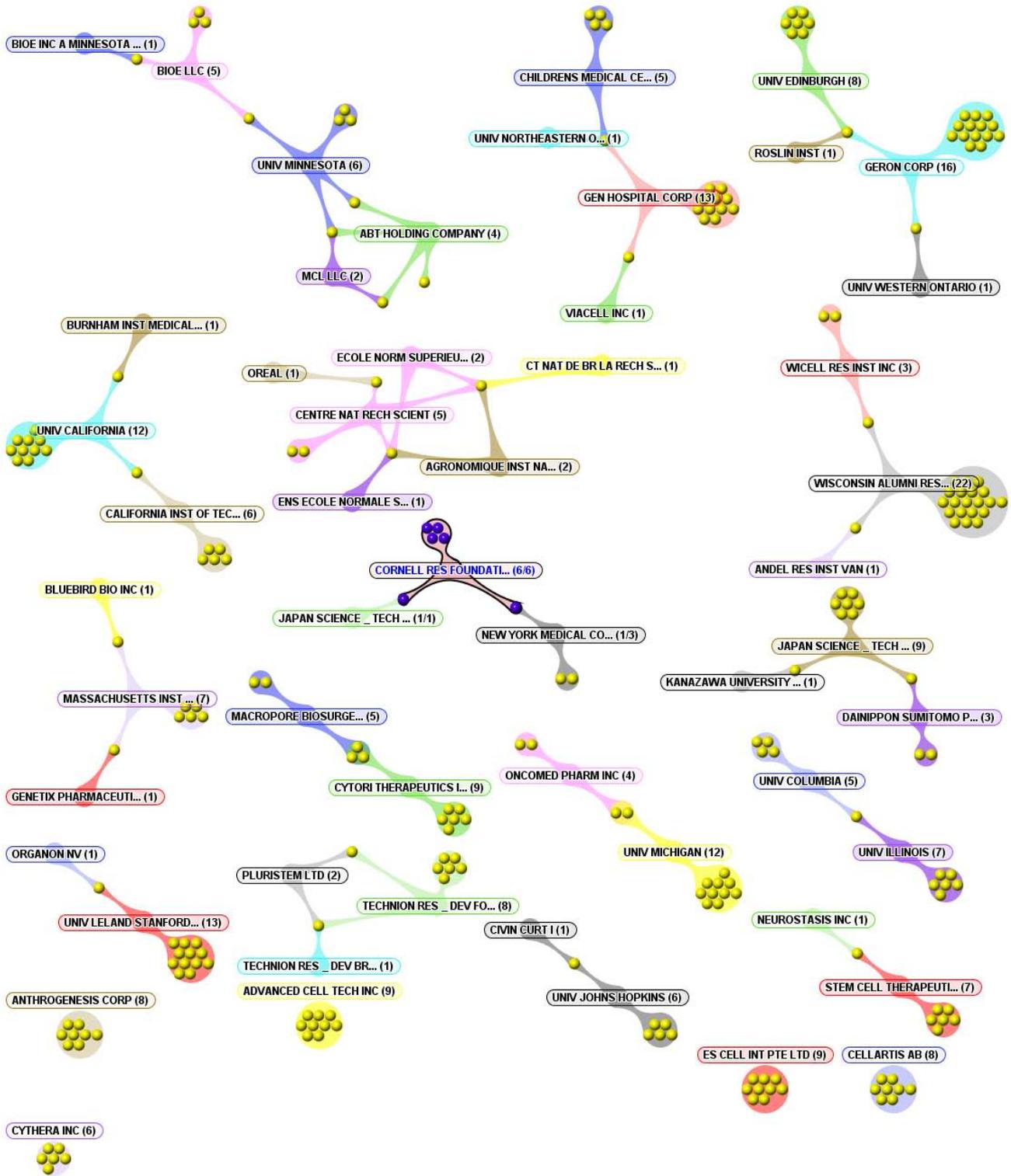


Figure 15: Collaboration map of top applicants of granted patents

## 2.7 Analysis by patent classification

Figure 16 to Figure 21 show a series of charts highlighting the top ECLA (European patent classification<sup>6</sup>) and IPC (International Patent Classification<sup>7</sup>) applied to the published patent applications and granted patents in the dataset.

Given that the focus of the UKNSCN patent watch service is to identify relevant stem cell patents, it is not surprising to see the top technology areas, as defined by the top ECLA sub-groups, being stem cell related. The top three sub-groups for published patent applications, as shown in Figure 16 are mesenchymal stem cells (C12N5/06B21P), pluripotent cells e.g. embryonic stem cells (C12N5/06B2P) and artificially induced pluripotent cells e.g. iPS (C12N5/06B3A).

For granted patents, the top three subgroups, as shown in Figure 17, are pluripotent cells e.g. embryonic stem cells (C12N5/06B2P), haematopoietic stem cells/uncommitted or multipotent progenitors (C12N5/06B11P), and stem cells/progenitor cells/precursor cells of the nervous system (C12N5/06B8P).

Given the timescales involved in granting patents, it follows that the ECLA and IPC sub-groups applied to the published patent applications give an indication of where more recent activity is taking place.

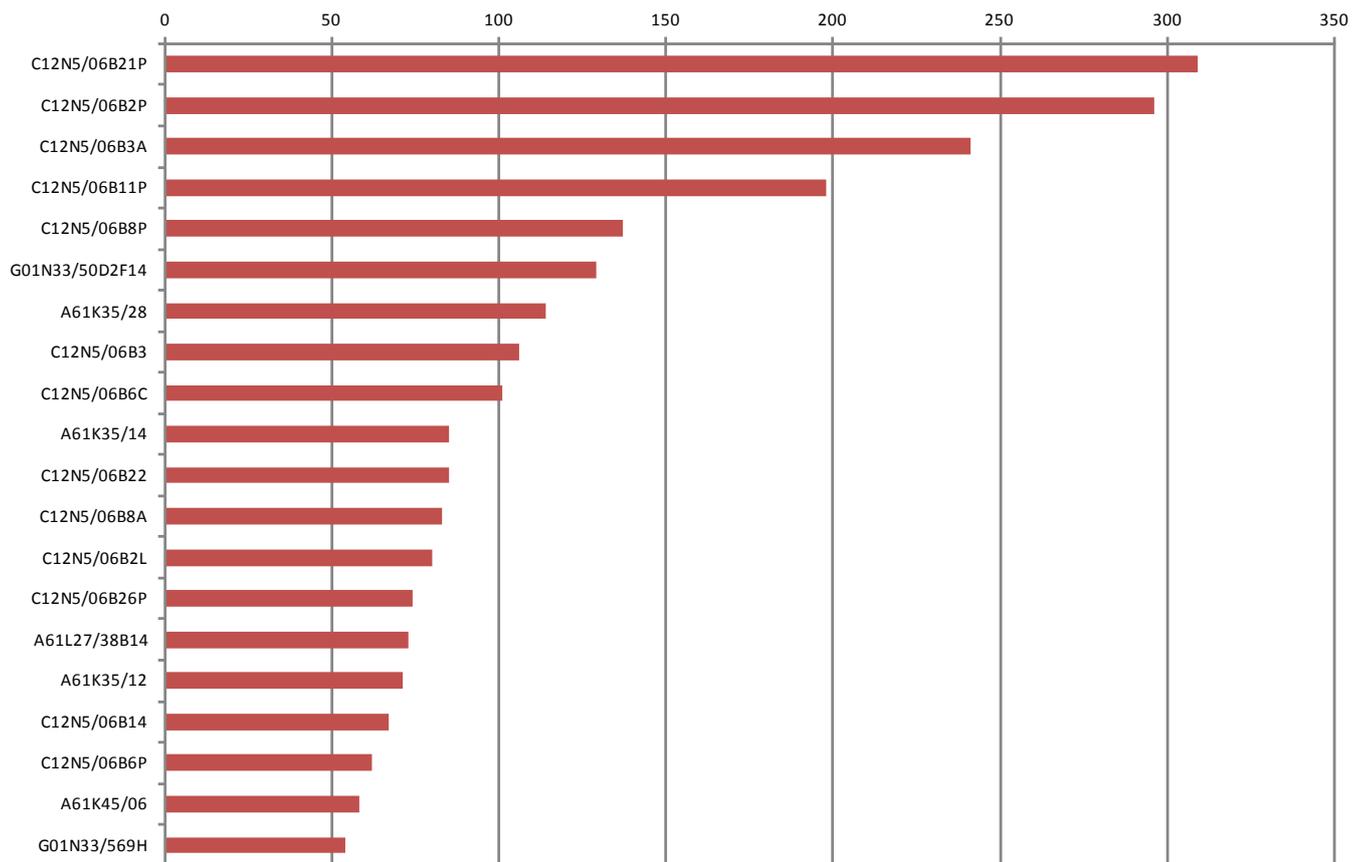


Figure 16: Top ECLA sub-groups of published patent applications

6 Specific ECLA terminology can be viewed online at [http://v3.espacenet.com/eclsrch?locale=en\\_V3&classification=ecla](http://v3.espacenet.com/eclsrch?locale=en_V3&classification=ecla)

7 Specific IPC terminology can be viewed online at <http://www.wipo.int/ipcpub/#refresh=page>

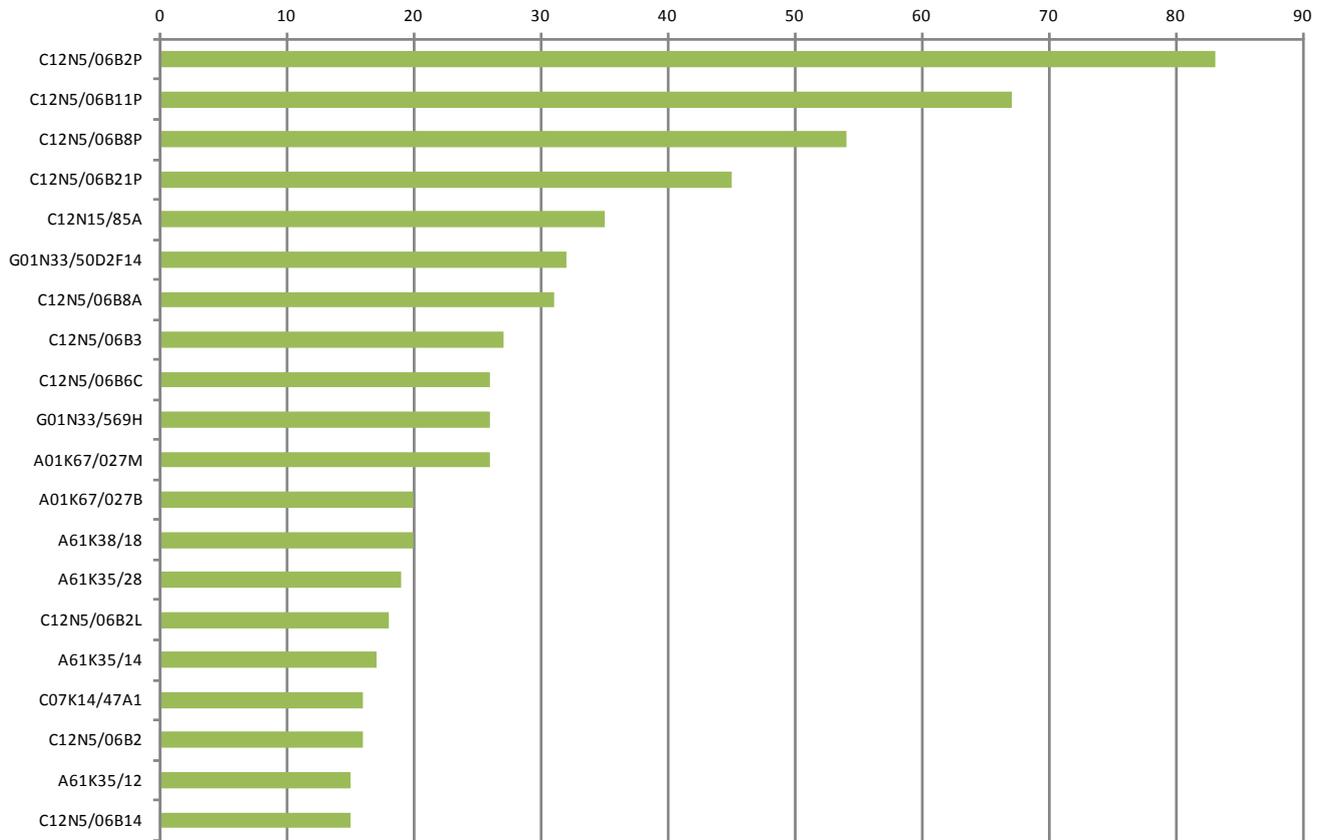


Figure 17: Top ECLA sub-groups of granted patents

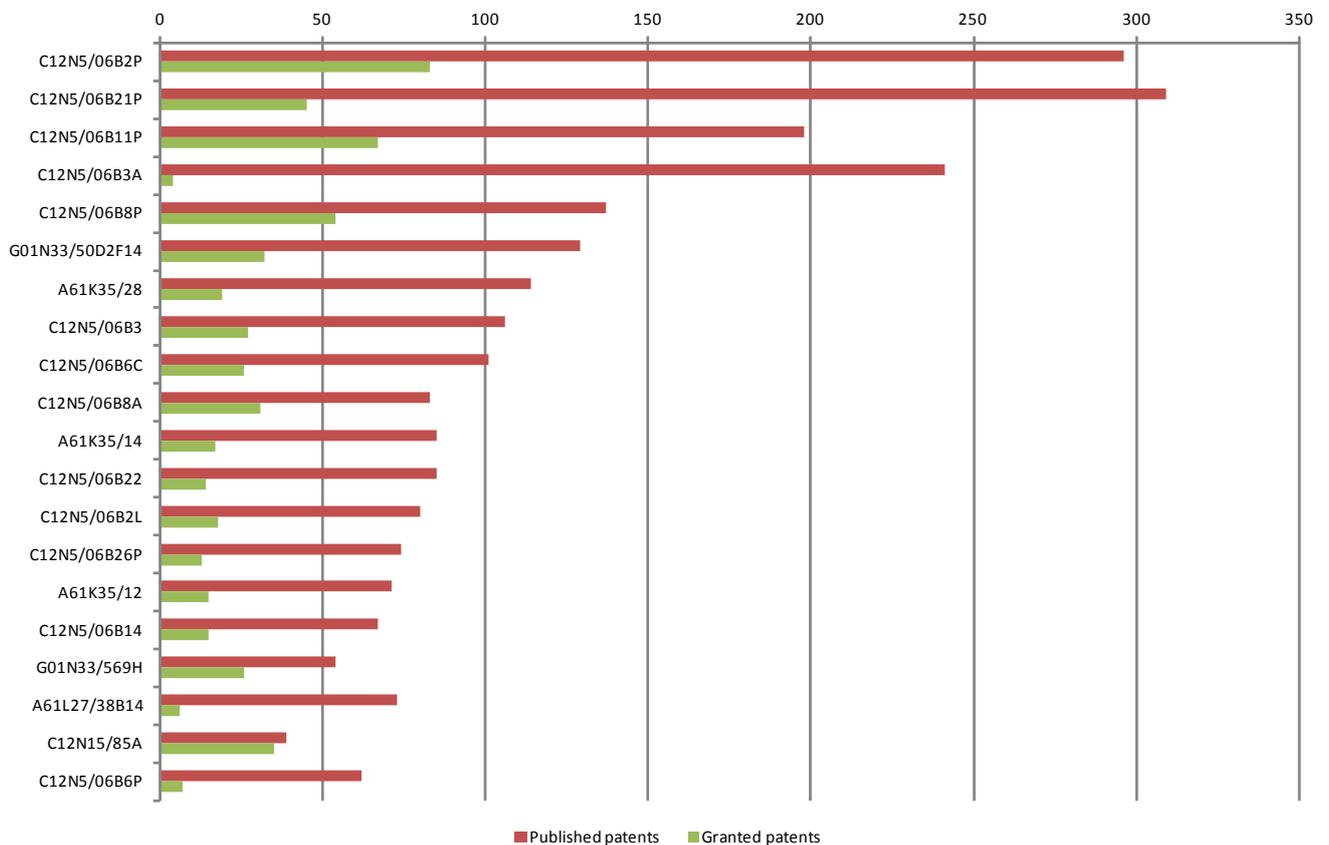


Figure 18: Comparison of top ECLA sub-groups for published patent applications and granted patents

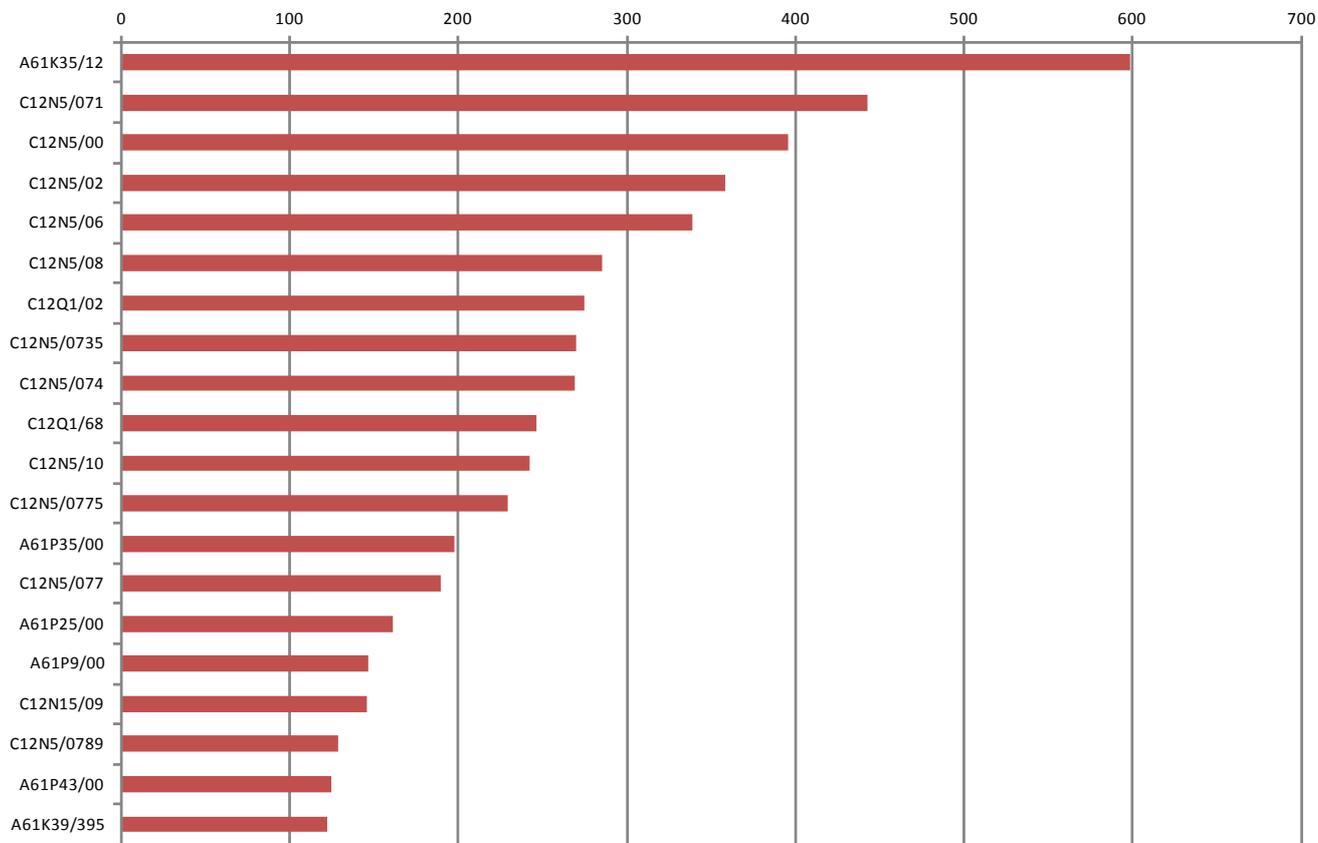


Figure 19: Top IPC sub-groups of published patent applications

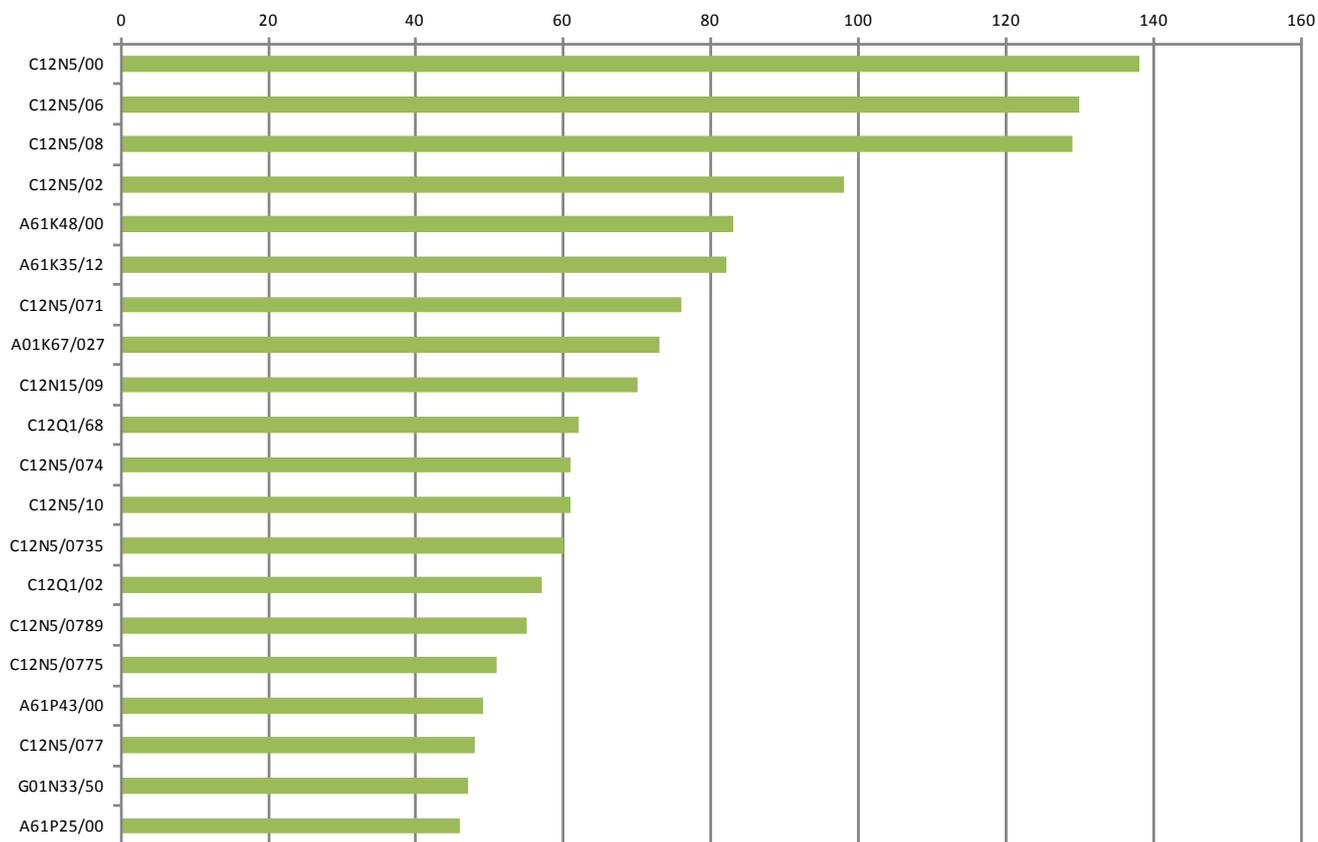


Figure 20: Top IPC sub-groups of granted patents

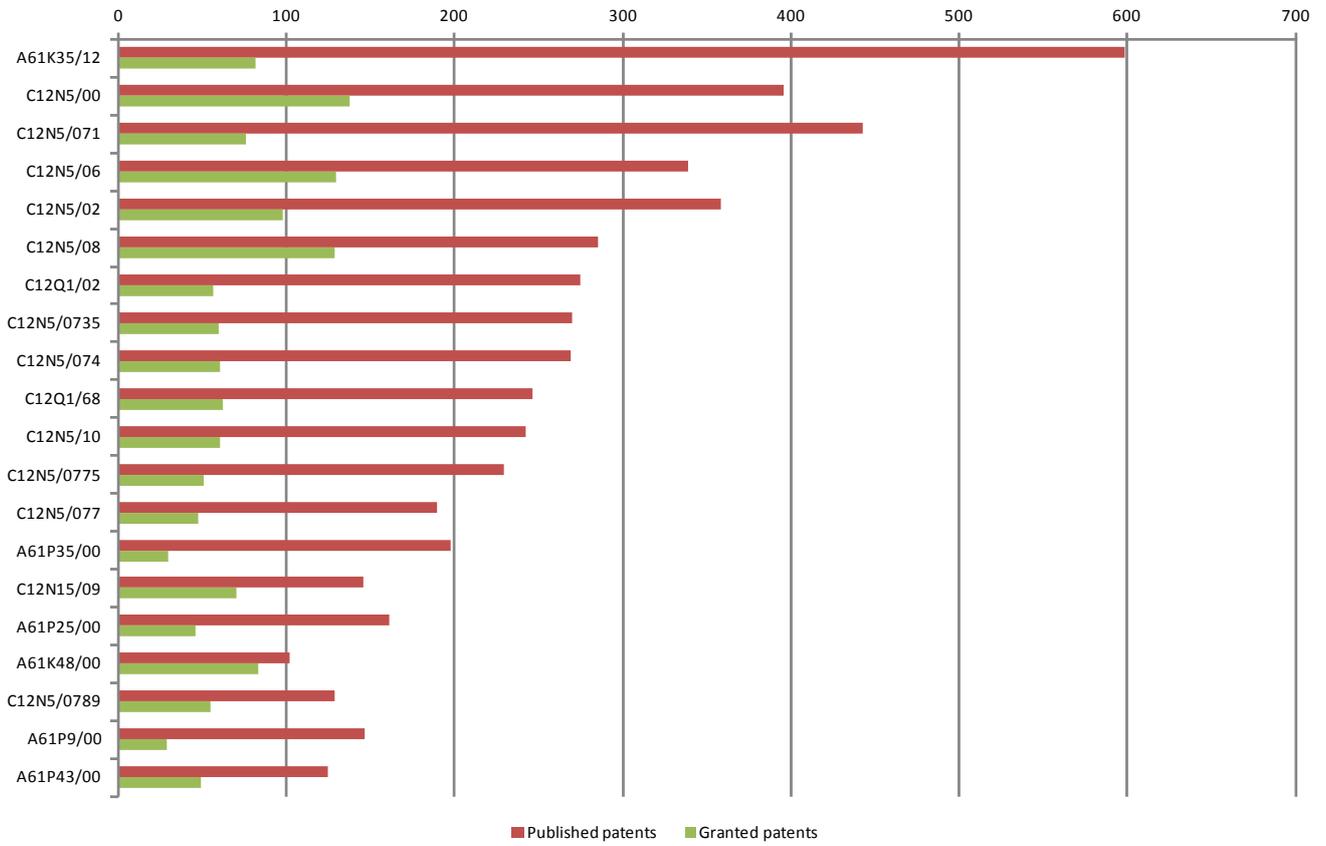


Figure 21: Comparison of top IPC sub-groups for published patent applications and granted patents

## 2.8 Analysis by stem cell technology area

The datasets were also sub-divided into four subsets relating to four different areas of interest using specific IPC sub-groups in the heading A61P. These subsets were chosen for the first patent landscape report in April 2010 because they encompassed the most clinically relevant applications and uses of stem cells; the same four areas are used in this report for comparison. Table 3 summarises the four different stem cell technology areas, the concordance with the IPC, and the size of the data subsets.

Technology area	IPC sub-groups	Published patents	Granted patents	Ratio of patents granted
Cardiovascular	A61P9/00 - A61P9/14	214	38	18%
Neurological	A61P25/00 - A61P25/36	228	55	24%
Ophthalmic	A61P27/02 - A61P27/14	37	11	30%
Antineoplastic	A61P35/00 - A61P35/04	228	32	14%

Table 3: Summary of different stem cell technology areas

Figure 22 to Figure 25 show how the four data subsets were analysed by sector and compared between the two date ranges used previously, and Figure 26 and Figure 27 show the distribution of each technology area by sector.

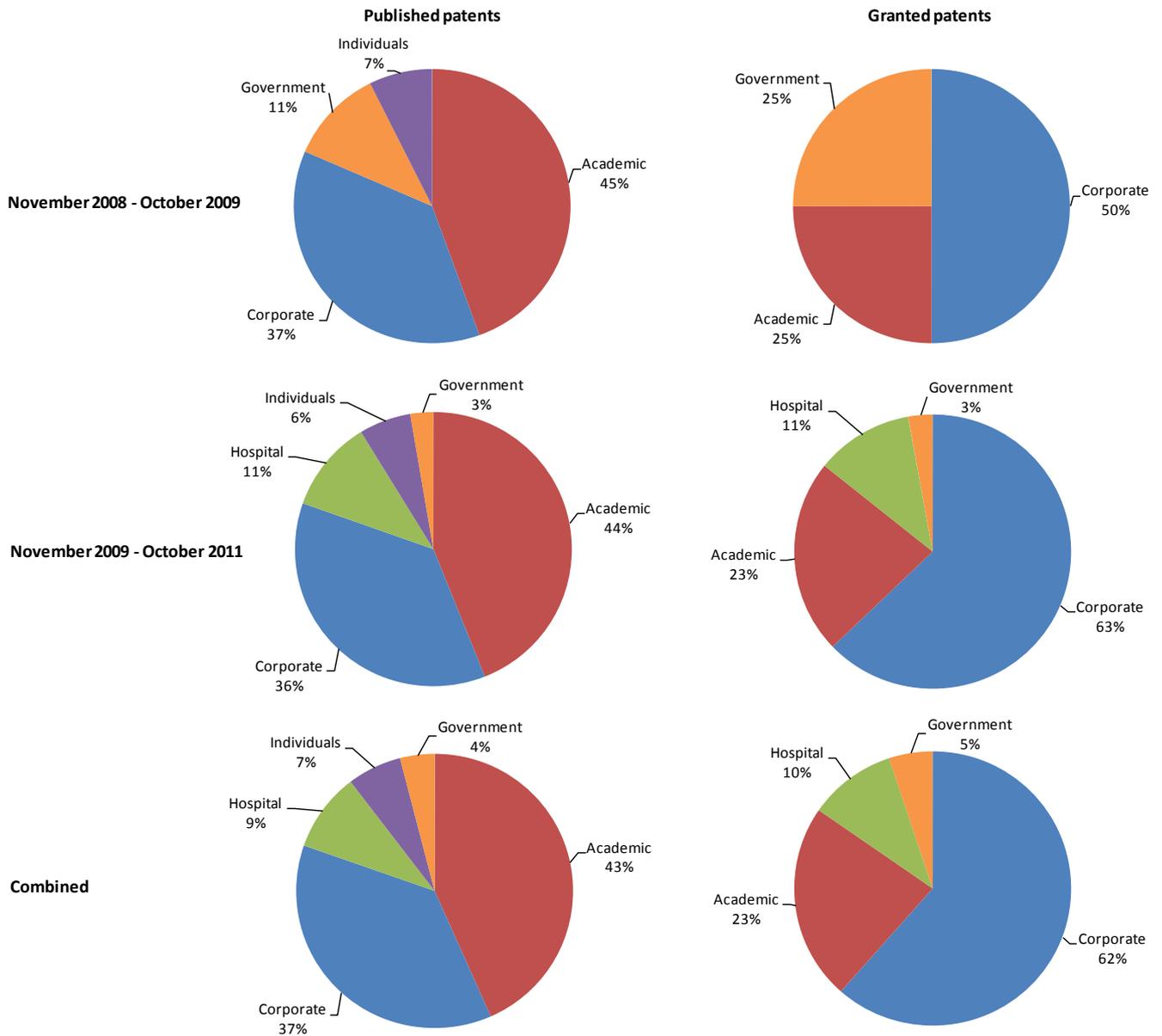


Figure 22: Sector breakdown of cardiovascular patents

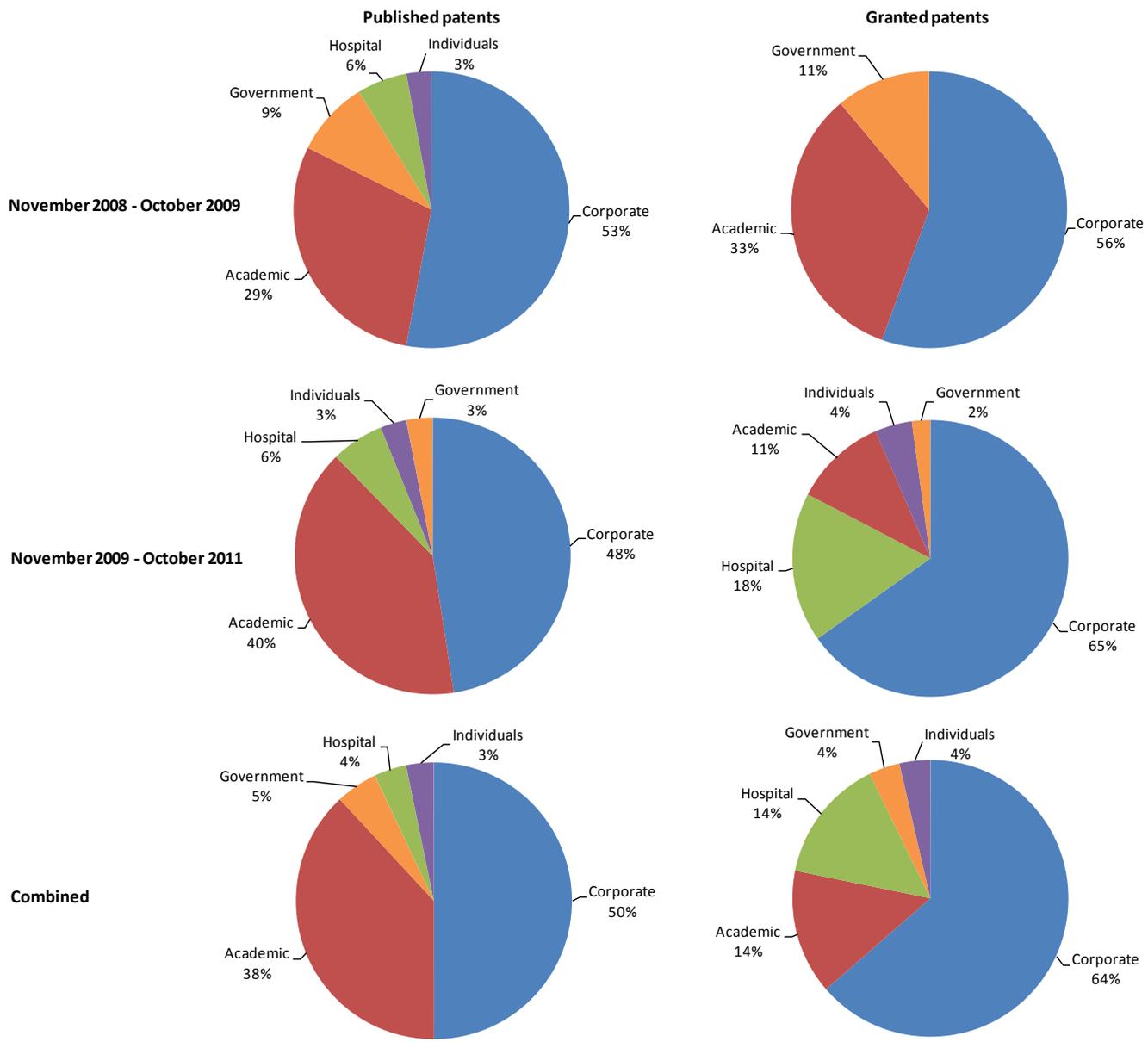


Figure 23: Sector breakdown of neurological patents

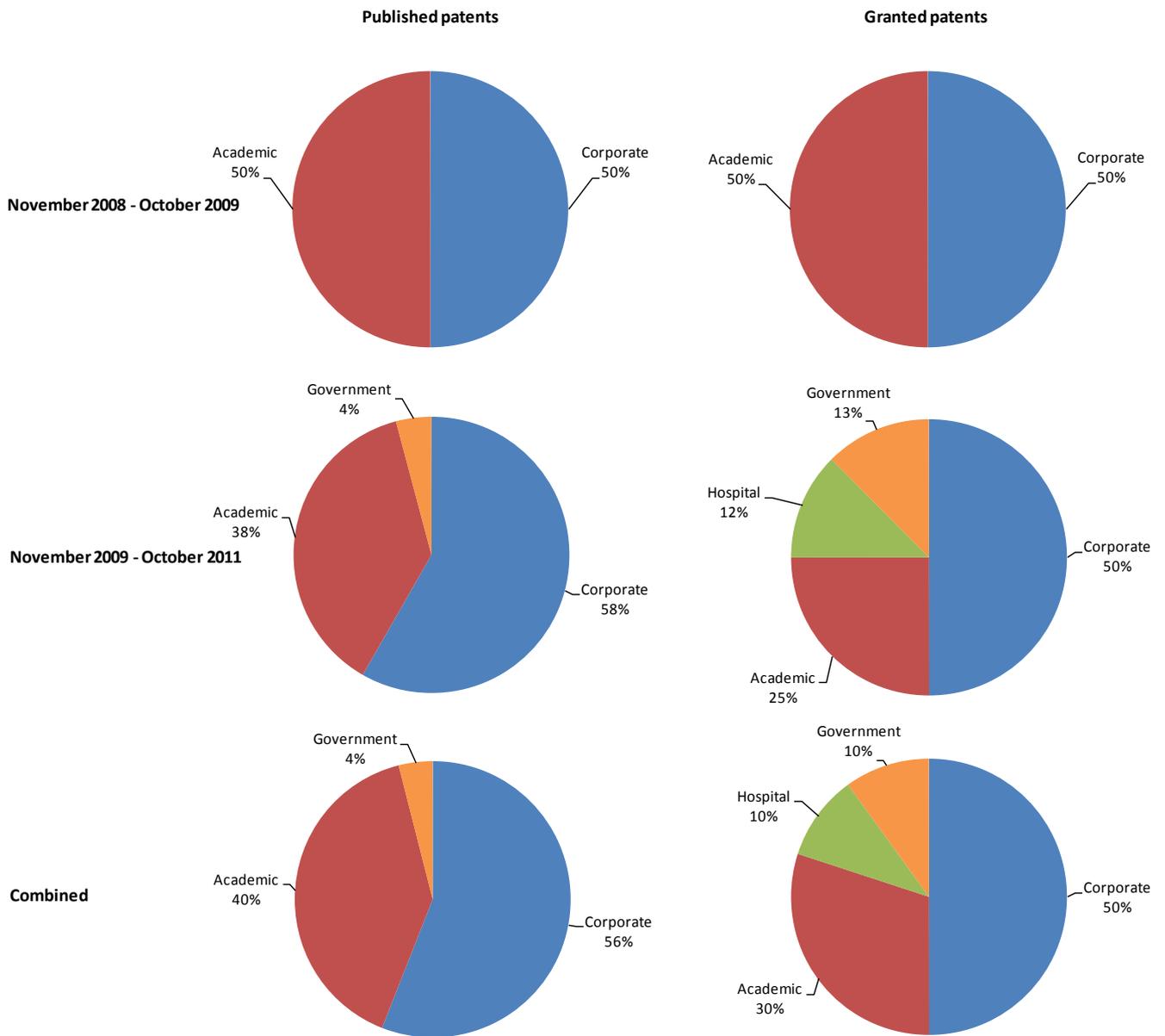


Figure 24: Sector breakdown of ophthalmic patents

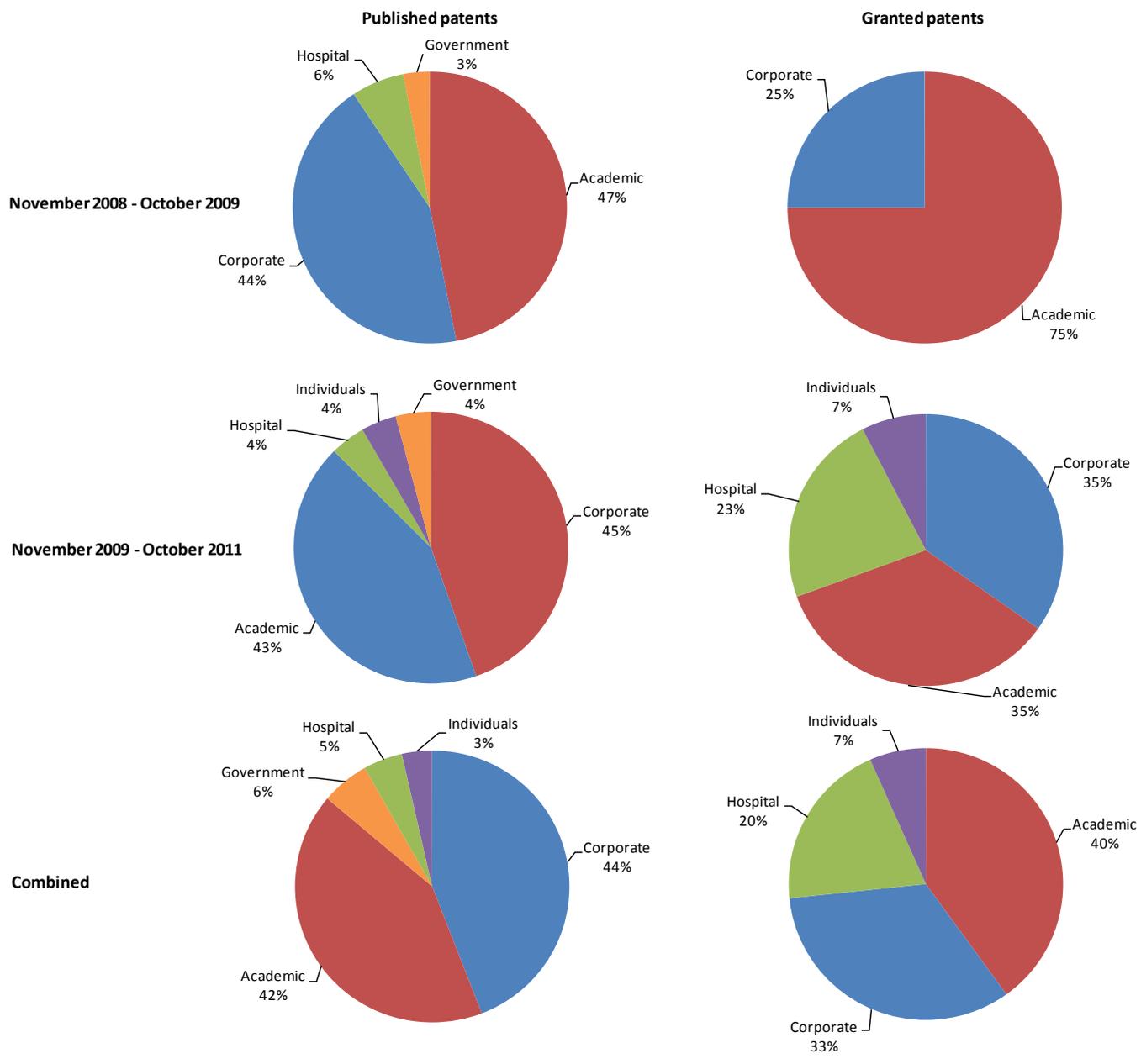


Figure 25: Sector breakdown of antineoplastic patents

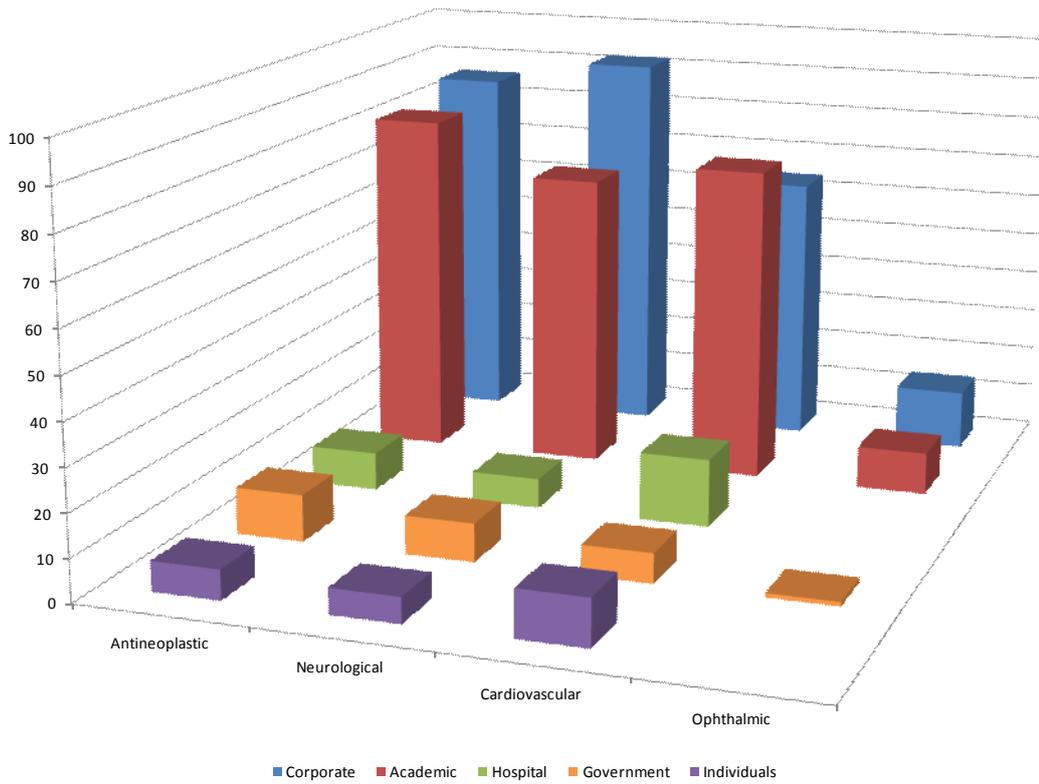


Figure 26: Distribution of each stem cell technology area by sector for the published patent applications

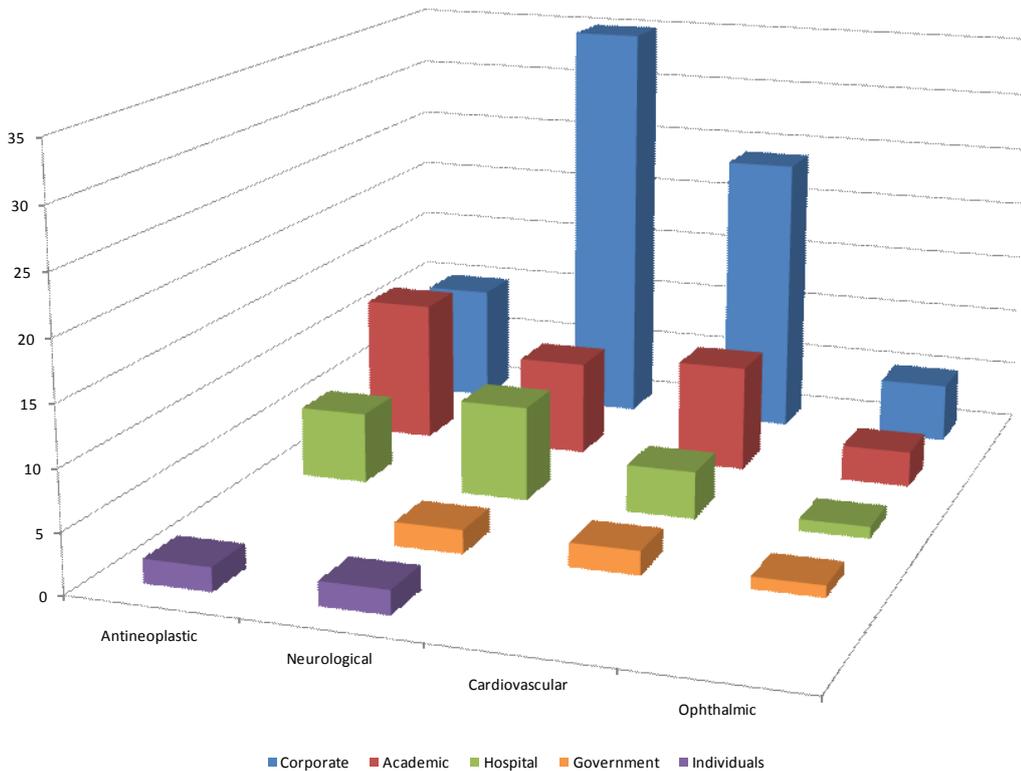


Figure 27: Distribution of each stem cell technology area by sector for the granted patents

## 2.9 Patent landscape map analysis

In order to give a snapshot as to what the UKNSCN patent watch patent landscape looks like, a patent map provides a visual representation of the dataset. Patents are represented on a patent map by dots and the more intense the concentration of patents (i.e. the more closely related they are) the higher the topography as shown by contour lines. The patents are grouped according to the occurrence of keywords in the title and abstract and examples of the reoccurring keywords appear on the patent map<sup>8</sup>.

A dataset combining all UKNSCN published patent applications and granted patents was used to produce the patent landscape shown in Figure 28. The two “snow-capped peaks” in the centre of the map shows that the highest concentration of patents in this dataset relate to patents comprising keywords such as “pluripotent” and “mesenchymal”, which is consistent with the top ECLA sub-groups discussed previously in section 2.7.

The patent landscape map shown in Figure 29 is the same patent map shown in Figure 28, but with specific patents (dots) highlighted. The map in Figure 29 highlights the granted stem cell patents and shows a fairly even spread across the whole stem cell patent landscape. Figure 30 to Figure 33 highlight the patents relating to the four stem cell technology areas discussed previously, with Figure 34 showing them all on one map and Figure 35 showing a rough approximation for the regions where patents relating to each of these four technology areas can be found. Figure 36 shows the location of published and granted patents from UK applicants and there appears to be no single area of stem cell specialism for UK applicants.

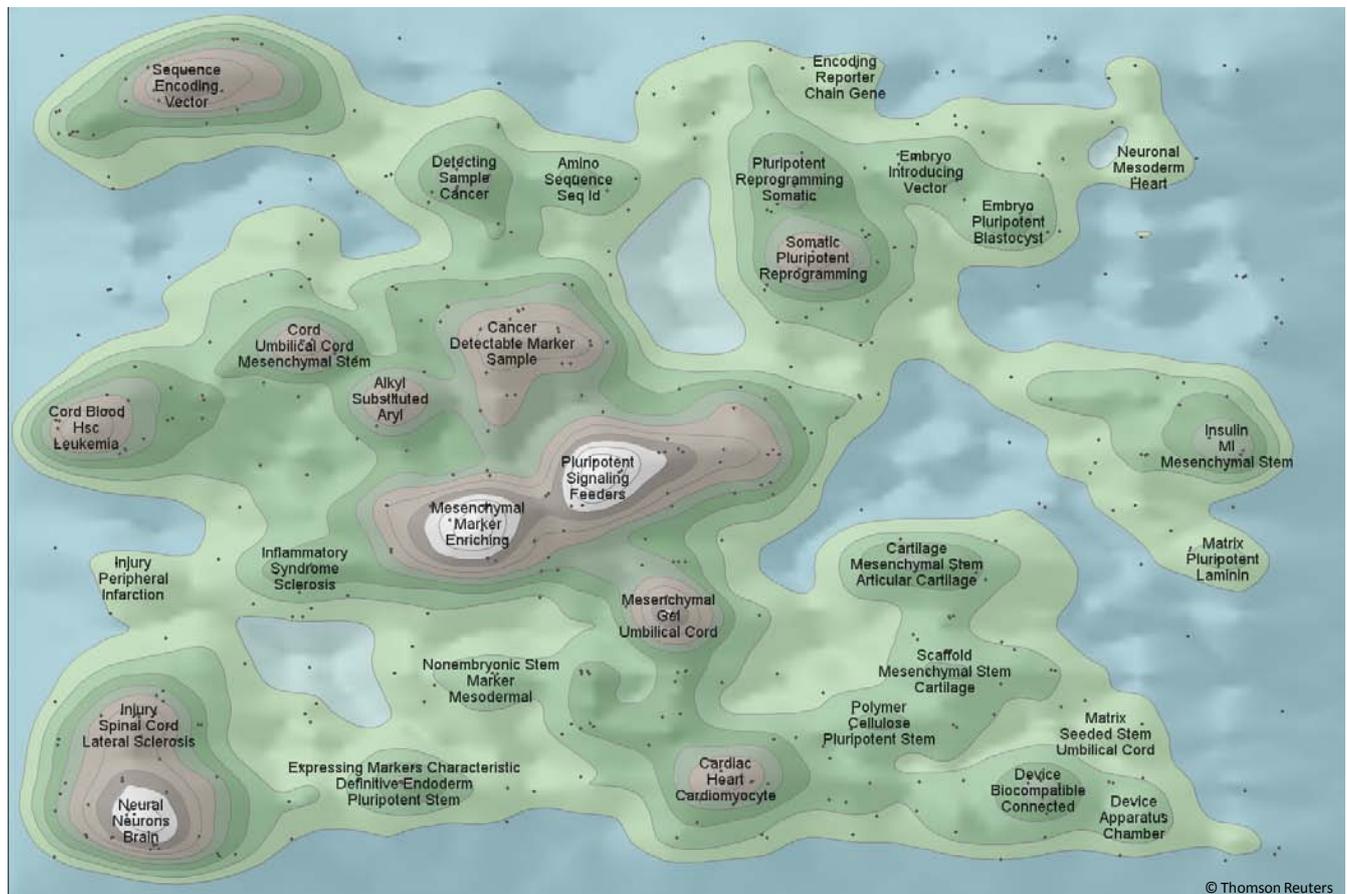


Figure 28: Patent landscape map of all published patent applications and granted patents

<sup>8</sup> Further details regarding how patent landscape maps are produced is given in Appendix C.

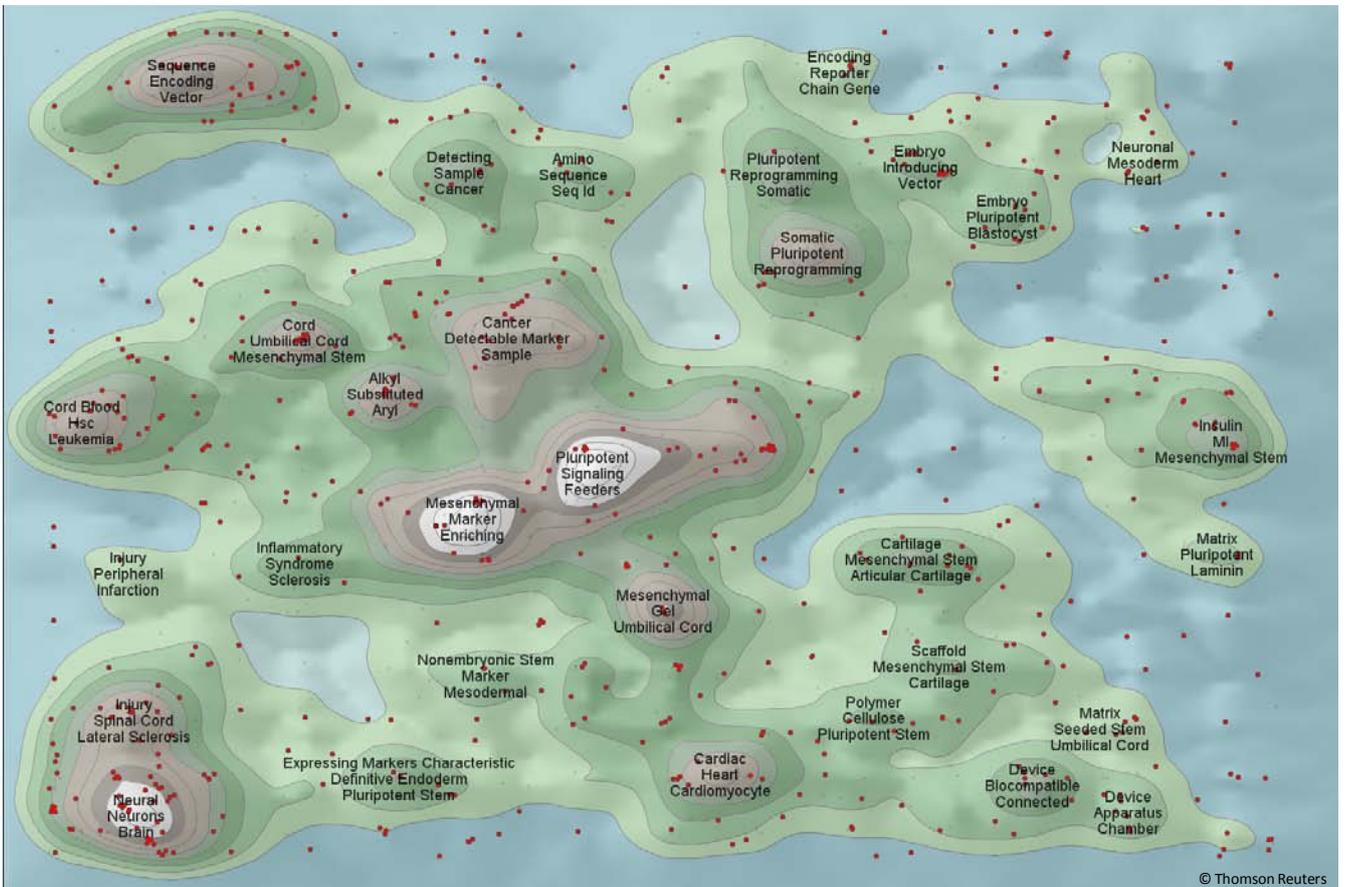


Figure 29: Patent landscape map showing all granted patents

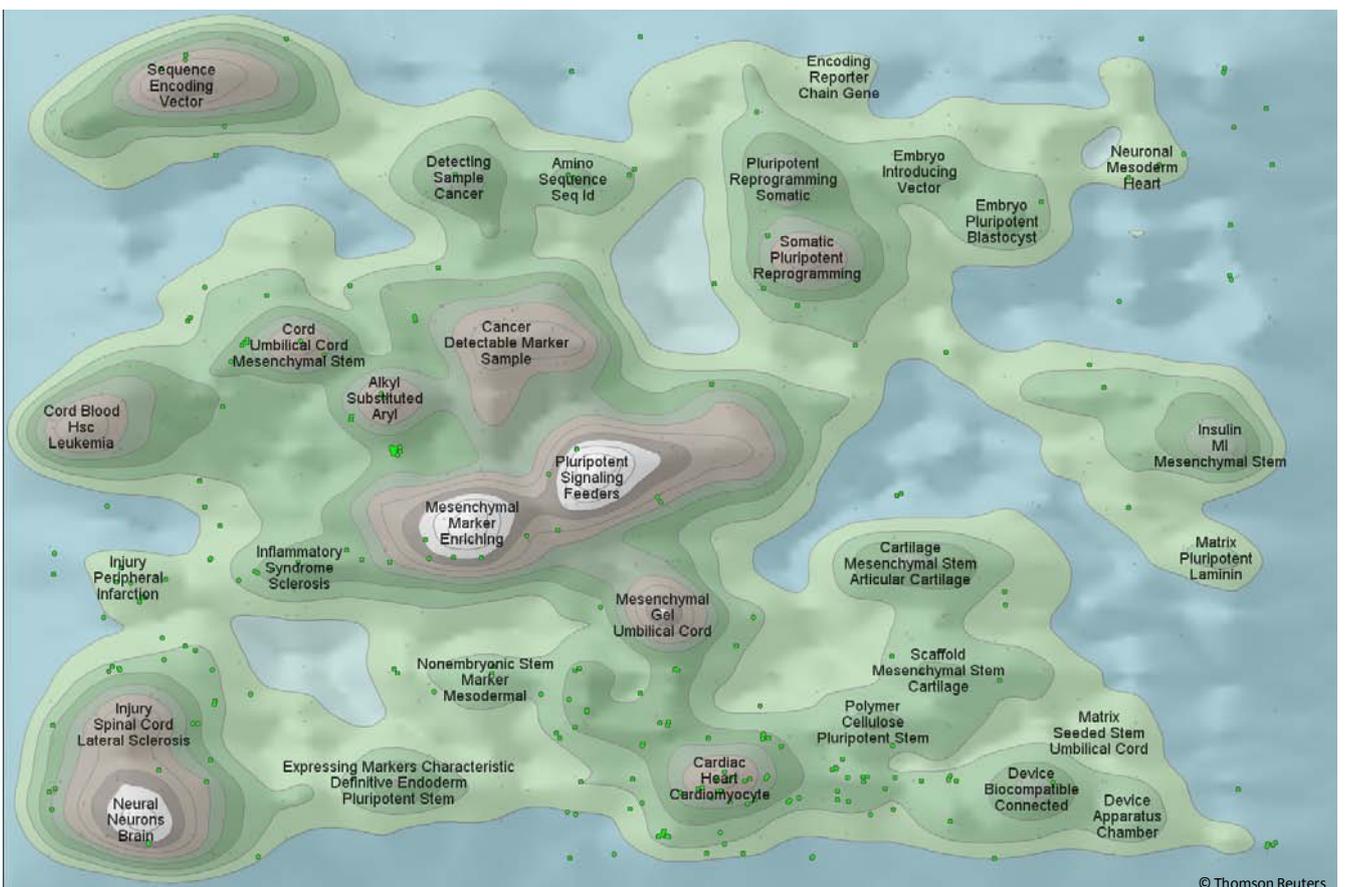


Figure 30: Patent landscape map showing all cardiovascular patents

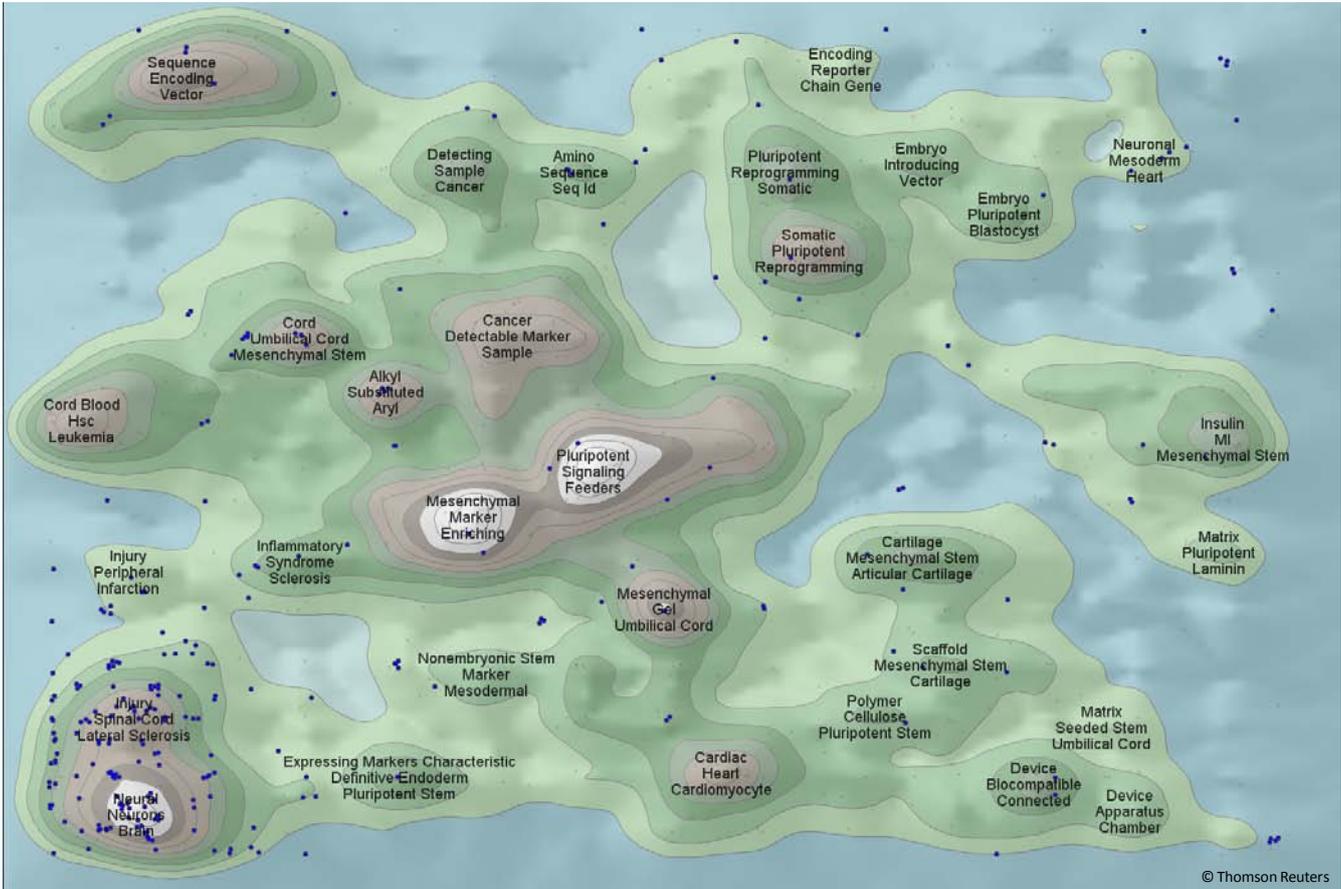


Figure 31: Patent landscape map showing all neurological patents

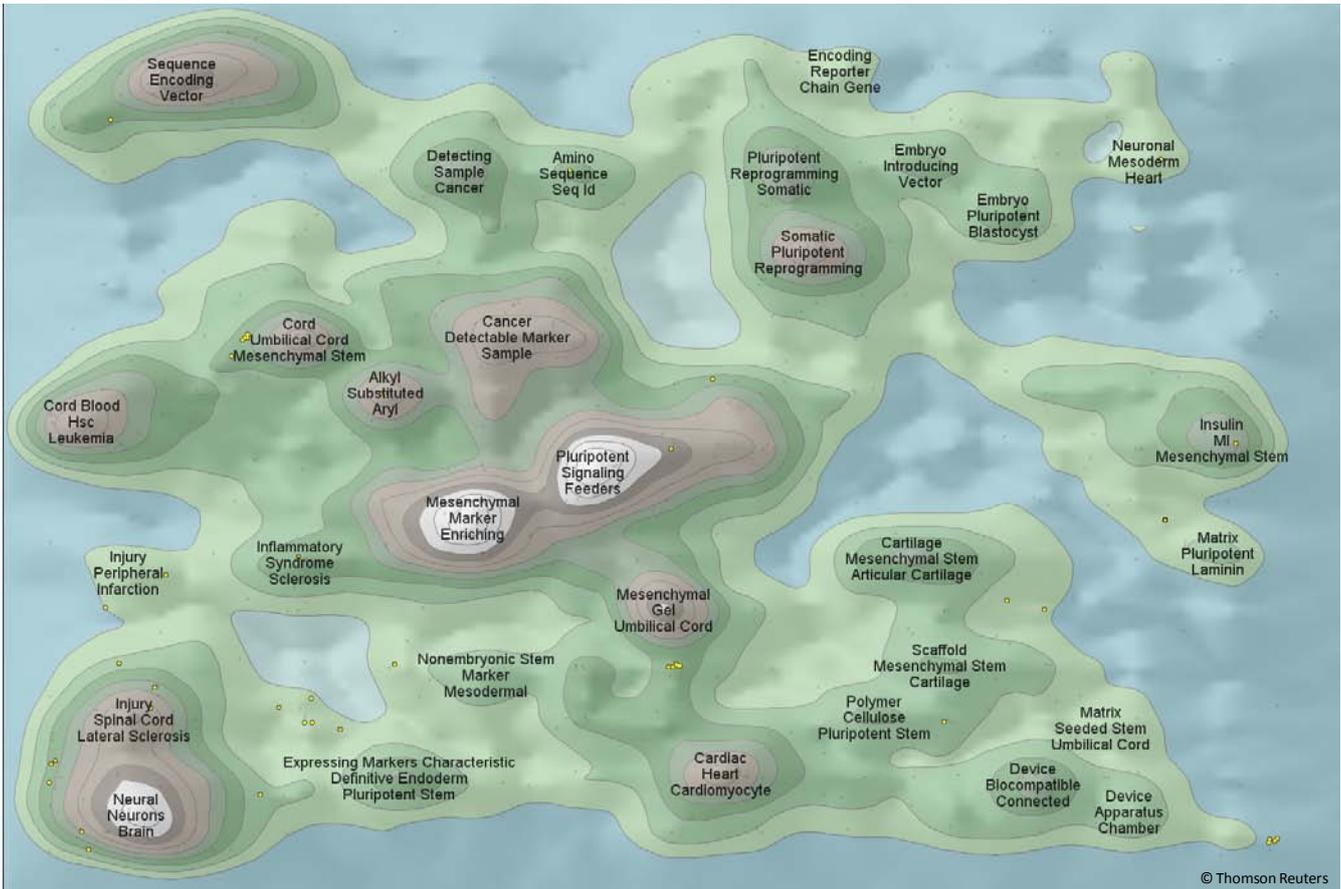
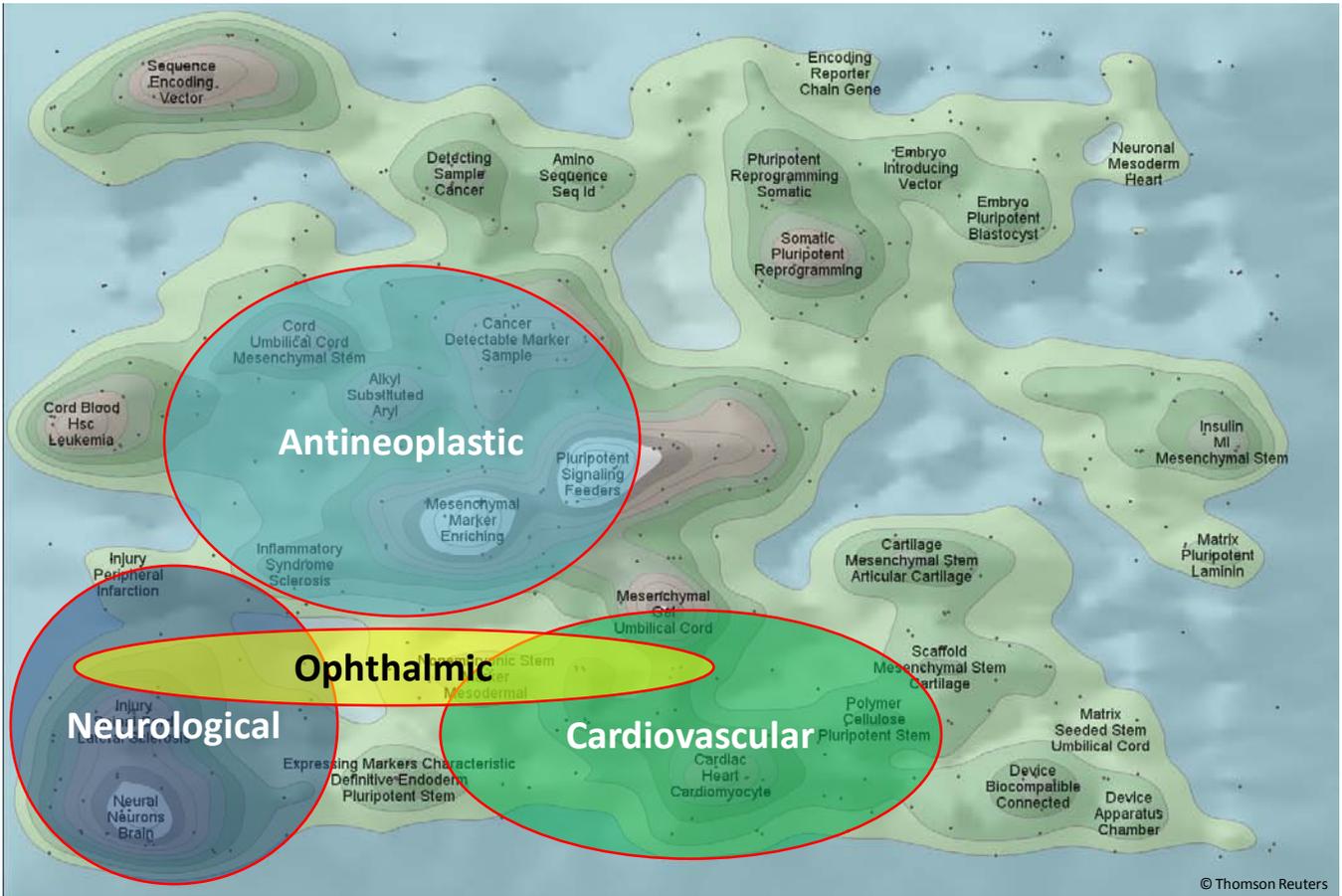


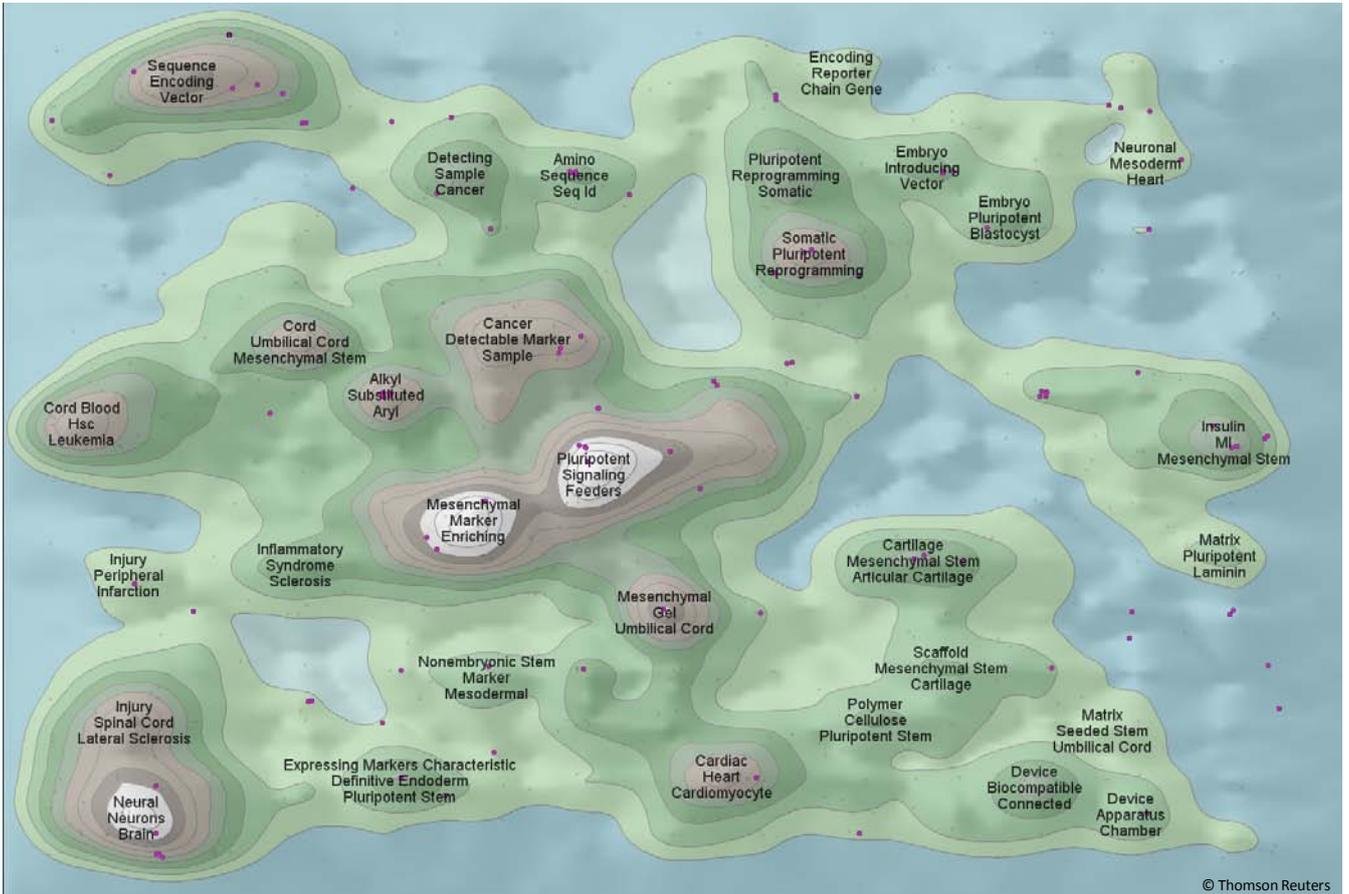
Figure 32: Patent landscape map showing all ophthalmic patents





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Figure 35: Patent landscape map highlighting approximate regions for each technology area



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Figure 36: Patent landscape map showing UK applicants

## Conclusions

The dataset of published patent applications and granted patents published between November 2008 and October 2011 and provided to the UKNSCN was analysed to provide a bigger picture regarding the patenting of stem cell technology. Comparisons have also been made between the data analysed in the April 2010 patent landscape report, which was based on the November 2008 to October 2009 UKNSCN data, and the patents published and granted more recently.

Corporations and academia account for over 85% of both published patent applications and granted stem cell patents, with corporations having a marginally higher market share. Despite the corporate sector having the majority market share, it is interesting to note that the top applicant of published patent applications is Kyoto University in Japan and the top applicant of granted patents is Wisconsin Alumni Research Foundation in the USA. The University of Edinburgh is the top UK applicant of both published patent applications and granted stem cell patents.

Due to lengthy patent pendency times, the more recent areas of research and new entrants into this area of technology will be reflected in the published patent applications rather than the granted patents. Analysis of the ECLA and IPC classifications applied to the published patent applications suggests that recent research is focussed on mesenchymal stem cells, pluripotent cells (e.g. embryonic stem cells) and artificially induced pluripotent cells (e.g. iPS). In general, the classification areas of granted patents suggest areas of research that were studied several years previously; the top three areas for granted stem cells patents are pluripotent cells (e.g. embryonic stem cells), haematopoietic stem cells/uncommitted or multipotent progenitors, and stem cells/progenitor cells/precursor cells of the nervous system. This suggests that embryonic stem cell research has been going on for many years now and is still on-going.

In the broader fields of neurological and ophthalmic patenting, the corporate sector has the majority of both published patent applications and granted patents. In antineoplastic areas, both the corporate and academic sectors have a similar market share of both published and granted patents. Academia holds the majority market share (43%) for published cardiovascular patent applications, but this is reversed for granted cardiovascular patents with corporations having over 60% of the market share. In all four technology areas studied, it is interesting to note how the market share of the hospital sector increases between published patent applications and granted patents (e.g. in the antineoplastic area, the hospital sector holds only 5% of all published patent applications, but yet it holds 20% of all granted patents); this could be because research in hospitals is very innovative and at the cutting-edge of stem cell research and so the ratio of granted patents to published patent applications for the hospital sector is higher than the other sectors.

The UKNSCN dataset is limited to patent applications published having WO, US, EP and GB designations, along with the granted US, EP and GB patents; hence, in order to place the results of the UK patent watch in a more global context and to give a fuller picture of the worldwide activity in relation to stem cells, an overview of the complete global dataset would be beneficial especially given the recent rise in worldwide patent filings from countries such as China and India.

## Appendix A Interpretation notes

### A.1 Priority date, application date and publication date

There are generally three dates which can be associated with a patent application as follows:

**Application date:**

The date on which an application for a patent was made.

**Priority date:**

The application date of an earlier, related patent application containing the same invention. A patent can claim a priority date from an earlier application which contains the same subject matter. The priority date is the earliest available indication of the date of invention.

**Publication date:**

The date when the patent application was published. This is normally 18 months after the priority date or the application date, whichever is the earlier.

### A.2 WO and EP patent applications

International patent applications (WO) and European Patent Applications (EP) may be made through the World Intellectual Property Organization (WIPO) and the European Patent Office (EPO) respectively.

International patent applications may designate any signatory states or regions to the Patent Cooperation Treaty (PCT) and will have the same effect as national or regional patent applications in each designated state or region, leading to a granted patent in each state or region.

European patent applications are regional patent applications which may designate any signatory state to the European Patent Convention (EPC), and lead to granted patents having the same effect as a bundle of national patents for the designated states.

Figures for patent families with WO and EP as priority country have been included for completeness although no single attributable country is immediately apparent.

### A.3 Patent documents analysed

The dataset was identified through European Classification (ECLA) and International Patent Classification (IPC) codes and word searching of abstracts in conjunction with patent examiner technology-specific expertise.

The UKNSCN patent digests contain details of the search strategy used but for completeness an exemplar EPOQUE<sup>9</sup> search strategy is reproduced below for patents published between 1 November 2008 and 31 October 2009:

**Search area (ECLA):**

1: /EC/ECNO OR C12N5/06B2P, C12N5/06B3, C12N5/06B6P, C12N5/06B8P, C12N5/06B11P, C12N5/06B12P, C12N5/06B14P, C12N5/06B18P, C12N5/06B20P, C12N5/06B21P, C12N5/06B22P, C12N5/06B26P, C12N5/06B28P, C12N5/06B30P, C12N5/06B3A

**Keywords:**

10: \* AND (STEM? OR PLURIPOTEN+ OR PROGENITOR? OR EMBRYO+ OR HBS OR BLASTOCYST? OR RE\_PROGRAM+ OR DE\_DIFFERENTIAT+ OR RETRO\_DIFFERENTIAT+ OR ?ESC?)

11: ((STEM? OR PLURIPOTEN+ OR EMBRYONIC+ OR PROGENITOR? OR EMBRYONAL+ OR HBS OR BLASTOCYST? OR DE\_DIFFERENTIAT+ OR RETRO\_DIFFERENTIAT+ OR ?ES OR RE\_PROGRAM+) 3D CELL?) OR (HESC? OR (HUMAN W ESC?) OR (PRIMATE W ESC?))

12: 1 OR 10 OR 11

13: ..LIM 12

14 PD<=2009-10-31 AND PD>2008-10-31  
– provides worldwide dataset of A publications

15: /PN B? w (OR 200811, 200812, 20090+, 200910)  
– provides worldwide dataset of B publications

16: /PN C? w (OR 200811, 200812, 20090+, 200910)  
– provides worldwide dataset of C publications

Any date attributed to a patent document is the priority date of that patent.

The applicant and inventor data is cleaned to remove duplicate entries arising from spelling errors, initialisation, international variation (Ltd, Pty, GmbH etc), or equivalence (Ltd., Limited, etc).

<sup>9</sup> EPOQUE is the European Patent Office (EPO) search system and is used for patent search and examination at the Intellectual Property Office.

## Appendix B Relative Specialisation Index (RSI)

Relative Specialisation Index (RSI) was calculated as a correction to absolute numbers of patents in order to account for the fact that some countries file more patent applications than others in all fields of technology. In particular, US and Japan inventors are prolific patentees. RSI compares the fraction of nanotechnology patents found in each country to the fraction of patents found in that country overall. A logarithm is applied to scale the fractions more suitably. The formula is given below:

$$\log_{10} \left( \frac{n_i/n_{\text{total}}}{N_i/N_{\text{total}}} \right)$$

where

$n_i$  = number of stem cell patents in country  $i$

$n_{\text{total}}$  = total number of stem cell patents in dataset

$N_i$  = total number of patents in country  $i$

$N_{\text{total}}$  = total number of patents in dataset

The effect of this is to highlight countries (in this study, Singapore in particular, as shown in Figure 9) which have a greater level of stem cell patenting than expected from their overall level of patenting, and which would otherwise languish much further down in the lists, unnoticed.

## Appendix C Patent landscape maps

A patent landscape map is a visual representation of a dataset (up to 60,000 patents can be used for each patent map) and is generated by applying a complex algorithm with four stages:

- 1 **Harvesting documents** – When the software harvests the documents it reads the text from each document (ranging from titles through to the full text). Non-relevant words, known as stopwords, (e.g. “a”, “an”, “able”, “about” etc) are then discounted and words with common stems are then associated together (e.g. “measure”, “measures”, “measuring”, “measurement” etc)
- 2 **Analysing documents** – Words are then analysed to see how many times they appear in each document in comparison with the words’ frequency in the overall dataset. During analysis, very frequently and very infrequently used words (i.e. words above and below a threshold) are eliminated from consideration. A topic list of statistically significant words is then created.
- 3 **Clustering documents** – A Naive Bayes classifier is used to assign document vectors and Vector Space Modelling is applied to plot documents in  $n$ -dimensional space (i.e. documents with similar topics are clustered around a central coordinate). The application of different vectors (i.e. topics) enables the relative positions of documents in  $n$ -dimensional space to be varied.
- 4 **Creating the patent map** – The final  $n$ -dimensional model is then rendered into a two dimensional map using a self-organising mapping algorithm. Contours are created to simulate a depth dimension. The final map can sometimes be misleading because it is important to interpret the map as if it were formed on a three dimensional sphere.

Thus, in summary, patents are represented on the patent map by dots and the more intense the concentration of patents (i.e. the more closely related they are) the higher the topography as shown by contour lines. The patents are grouped according to the occurrence of keywords in the title and abstract and examples of the reoccurring keywords appear on the patent map. However, there is no relationship between the patent landscape maps and any geographical map.



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