

# Analysis of intellectual properties on animal-derived regenerative, implantable medical devices

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## Abstract

This article analyses and summarizes issues of intellectual property involved in animal-derived regenerative, implantable medical devices (ADRIMD) in order to better understand global trends in patent applications and disclosures, the legal status of patent families (i.e. sets of patents filed in various countries to protect a single invention), and International Patent Classification topics such as main assignee and core expertise. Analysis of research trends will enhance and inform the decision-making capacity of researchers, investors, government regulators and other stakeholders as they undertake to develop, deploy, invest in or regulate ADRIMD.

**Keywords:** intellectual properties analysis; animal-derived medical device; tissue engineering; regenerative implantable medical device

## Introduction

Since research of animal-derived regenerative, implantable medical devices (ADRIMD) based on tissue engineering technology began in the 1980s [1–3], rapid progress has been made in the fields of biomaterials, biocompatibility, seed cells and tissue construction consequent to the efforts of scientists [4–6] and the support of relevant authorities. However, with respect to issues of intellectual property involved in ADRIMD, global scrutiny and analysis of these issues has not occurred at a pace consistent with scientific and industrial progress in developing and deploying ADRIMD. This article analyses and summarizes issues of intellectual property salient to ADRIMD research and provides predictions as to the global, national, local and individual competitive power of ADRIMD, as well as research trends, in order to provide decision-makers—researchers and clinicians, government and non-governmental organizations, investment companies and other relevant stakeholders—with the data needed to make and pursue wise policies.

## Data and Methods

### Data

Data concerning ADRIMD as intellectual property was gathered from European Patent Office, United States Patent and Trademark Office,

Queatel, global patent database, as well [7] using the following retrieval terms and phrasing: (Implant OR Implant\* device\* OR medical device\* OR Biomaterial\* OR filling material\* OR Prosthesis OR infilling OR filler OR Artificial Organ\* OR Biocompatible Material\*) AND Regenerate\* AND (animal origin\* OR animal source\* OR animal derive\* OR animal tissue\* OR animal organ\* OR animal tissues “and” their derivative\*). As of the 30 June 2014, the search had elicited 7447 (Patent family, in which 5578 effective patent family).

### Methods

Patent Bibliometrics or Patentometrics [8] was conducted using a bibliometric analysis based on patent documentations, in particular, with respect to annual applications and disclosure of patent families, legal status of specific patents, International Patent Classification (IPC), technical fields, main assignee, clustering analysis of technical topics and so on.

Of note: a patent family [9] refers to a set of patents filed in various countries to protect a single invention (when a first application in a country—the priority—is then extended to other offices). In other words, a patent family is ‘the same invention disclosed by a common inventor(s) and patented in more than one country’ [10]. Patent families can be regarded as a ‘fortuitous by-product of the concept of priorities for patent applications’ [11].

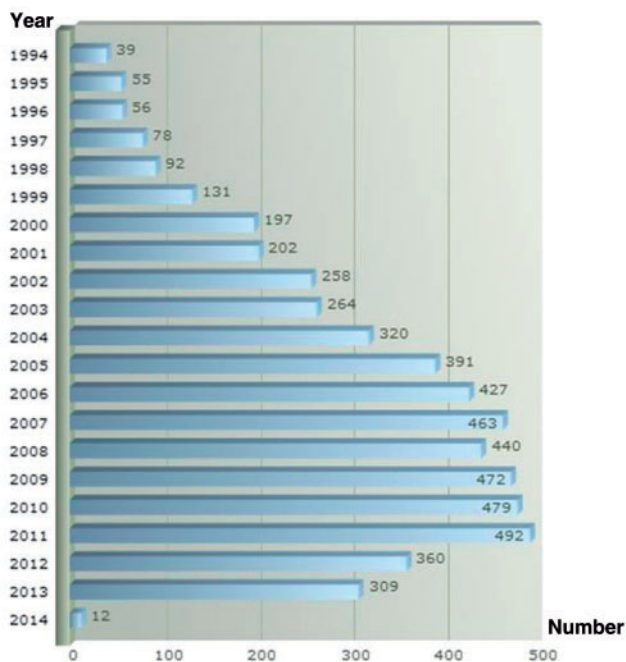


Figure 1. Annual patent applications

## Results

### Trends in annual applications

The first application for intellectual property rights with respect to ADRIMD appeared in 1994, peaking in 2011 with 492 patent applications, and declining annually thereafter (Fig. 1). Analysis of the legal status of applications found that, prior to 2009, the number of patents granted exceeded the number of pending applications, but that, after 2010, the trend reversed, with the number of pending applications exceeding the numbers of patents granted (Fig. 2).

### Trends analysis of annual disclosure patents

Disclosure patent appeared in 1994. The number increased steadily until it reached the peak in 2011 (As shown in Fig. 3). The granted patents were more than pending patents before 2012 while fewer after 2013 (Fig. 4).

### Analysis of the main technical fields

#### Technical composition of main IPC [10]

The four main groups (A61K038/00, A61P035/00, C12N015/00 and A61P043/00) added up to 46%, were main technical fields in ADRIMD, as shown in Fig. 5.

#### The legal status of main technology of IPC

According to the result of analyzing statistics, the granted patents are more than pending patents in the field of ADRIMD. It can be inferred that the technology of ADRIMD is mature (As shown in Fig. 6). A61K-038 (medicinal preparations containing peptides) has the largest share of patent rights whereas C12N-015 (mutation or genetic engineering, DNA or RNA concerning genetic engineering, vectors, such as plasmids, concerning their isolation, preparation or purification) has largest applications.

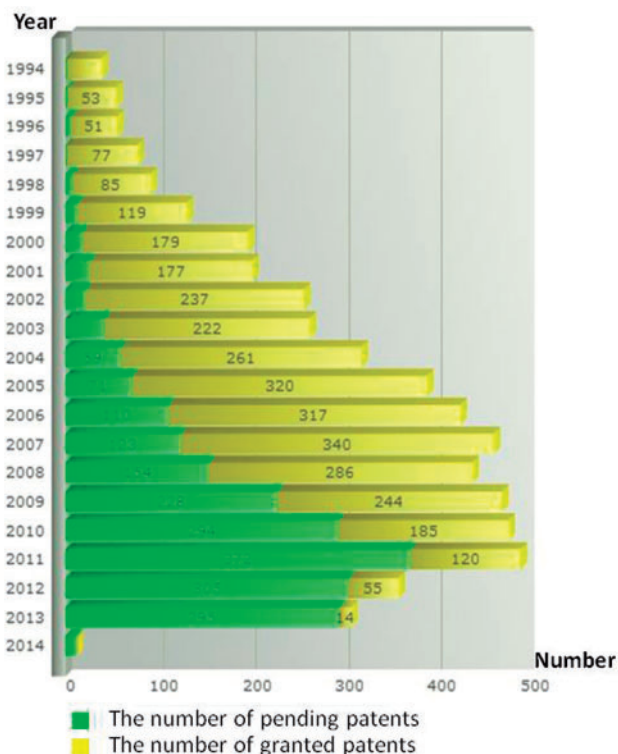


Figure 2. Legal status of patent applications

### Trend analysis of applications in main IPC technologies

The four main groups (A61K038/00, A61P035/00, C12N015/00 and A61P043/00) have had applications in each year since 1994 and the number of their applications increased year by year. But comparatively speaking, the applications of C12N-015 and A61P-043 were more than the other two groups (Fig. 7).

### Analysis of the main assignee

#### Patent family share of main assignee (Top 15 applicants)

The top four assignees are ZYMOGENETICS, US NIH (National Institutes of Health), GENENTECH and HUMAN GENOME SCIENCES. The difference among their shares is little. But they are in the lead with formidable advantages compared with other assignees (Fig. 8).

#### Application technical fields of main assignee (Top 10 assignees)

The application technical fields of top 10 assignees are A61K038/00, A61P035/00, C12N015/00 and A61P043/00. GENENTECH has the largest share in A61P035/00, C12N015/00 and A61P043/00 whereas HUMAN GENOME SCIENCES has the largest share in A61K038/00 (Fig. 9).

#### The legal status of main assignees

The main legal statuses of ADRIMD are granted and pending. The dominance of the granted patents indicates that the technology is mature (Fig. 10).

#### Application frequency of main assignees (Top 10)

The ADRIMD assignees with more than once application frequency are BASF (five times), Harvard College (three times) and University of California (five times) (Fig. 11).

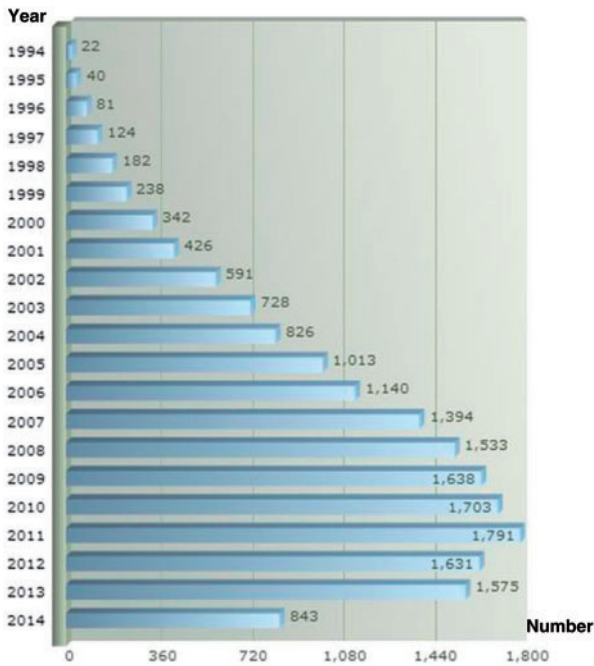


Figure 3. Number of disclosure patents

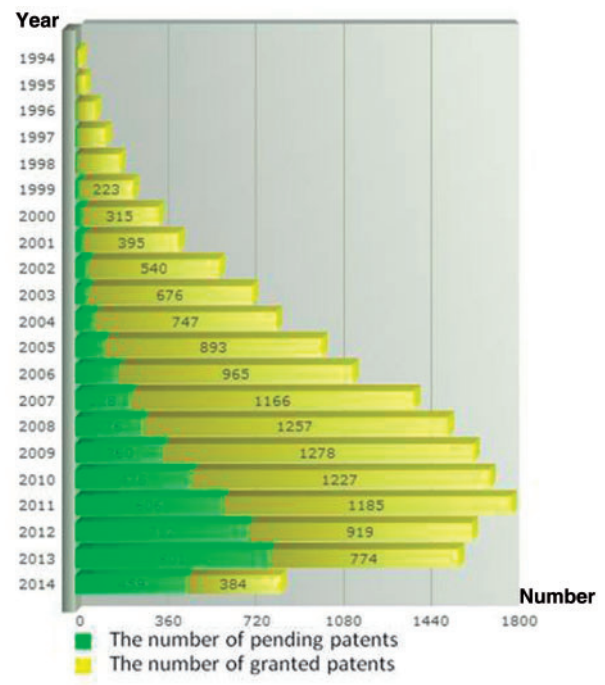


Figure 4. Legal status of disclosure patents

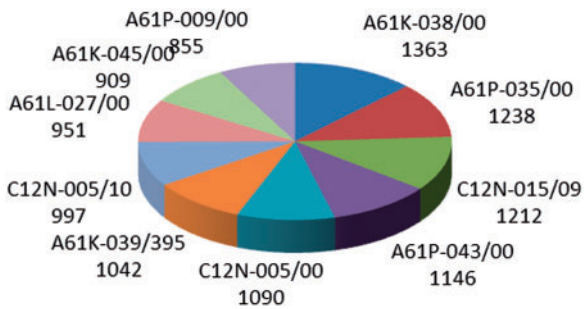


Figure 5. Main technical fields in ADRIMD

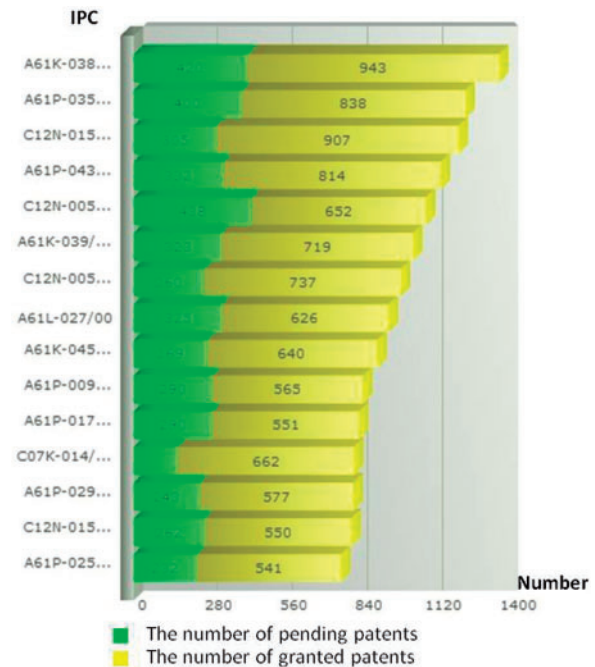


Figure 6. Legal status of patent in main technology fields

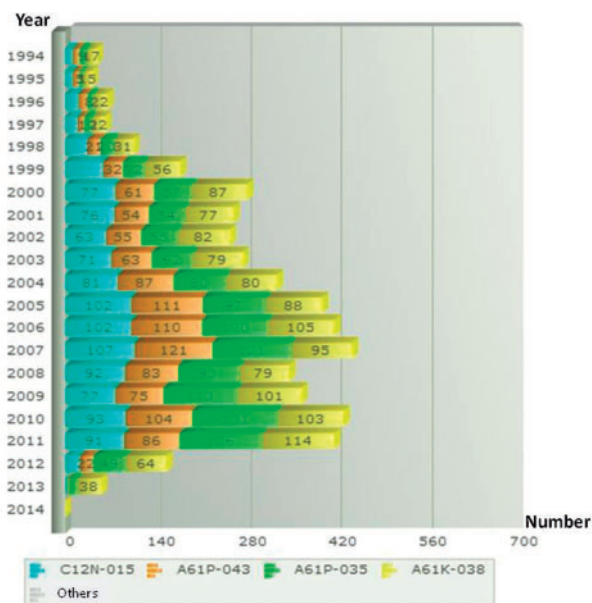


Figure 7. Annual applications of patent in main technology fields

Citation analysis of main assignees

In the light of the results, the top three assignees with the highest frequencies of being cited are HUMAN GENOME SCIENCES, GENENTECH and US NIH. They hold the largest patent family share and are cited more than other assignees (Fig. 12).

Earliest priority years of main assignees

The results are shown in Fig. 13. ZYMOGENETICS is the one with the fastest development among those main assignees. It applied its

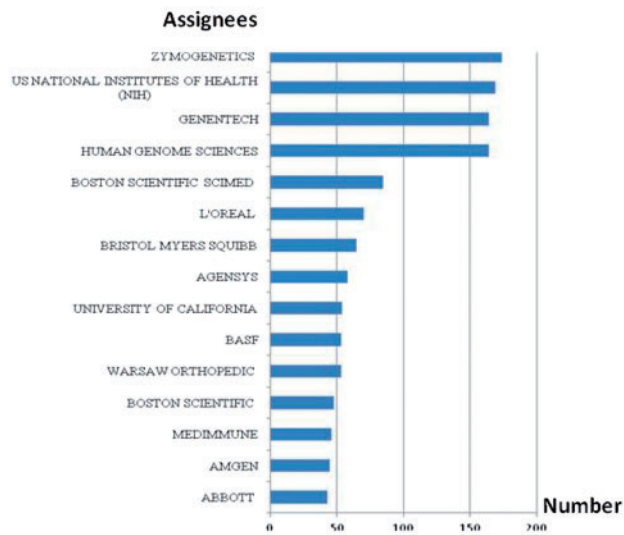


Figure 8. Patent family share of assignees

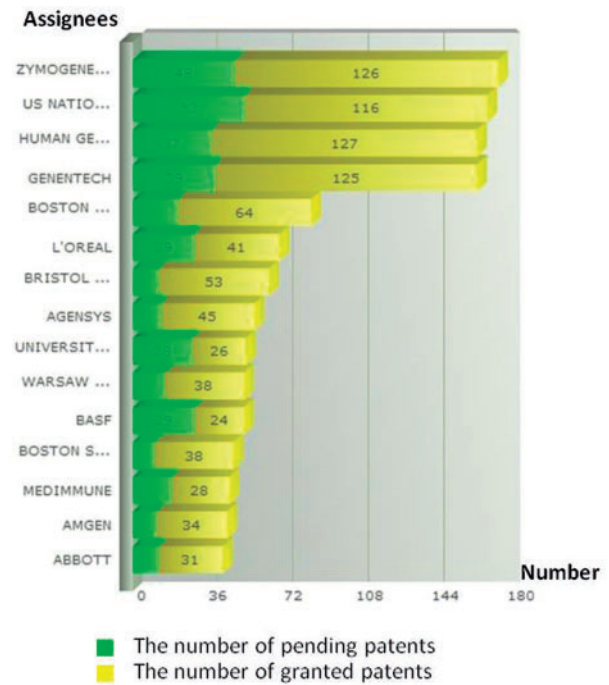


Figure 10. Legal status of assignees

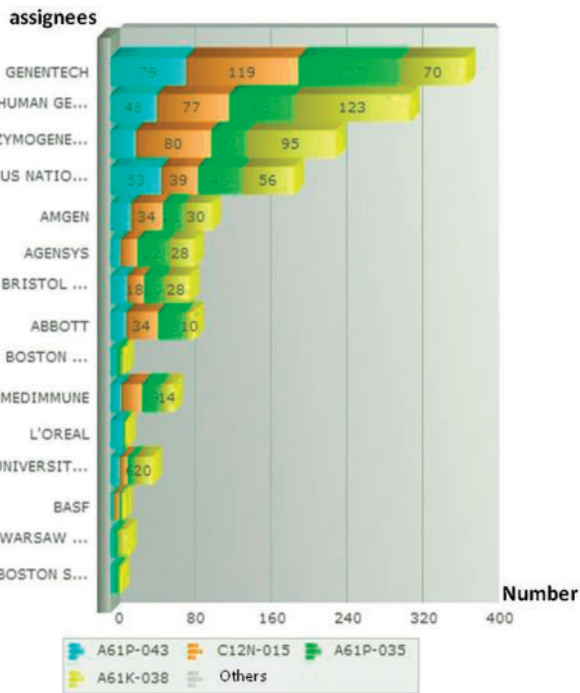


Figure 9. Main technology fields of assignees applied

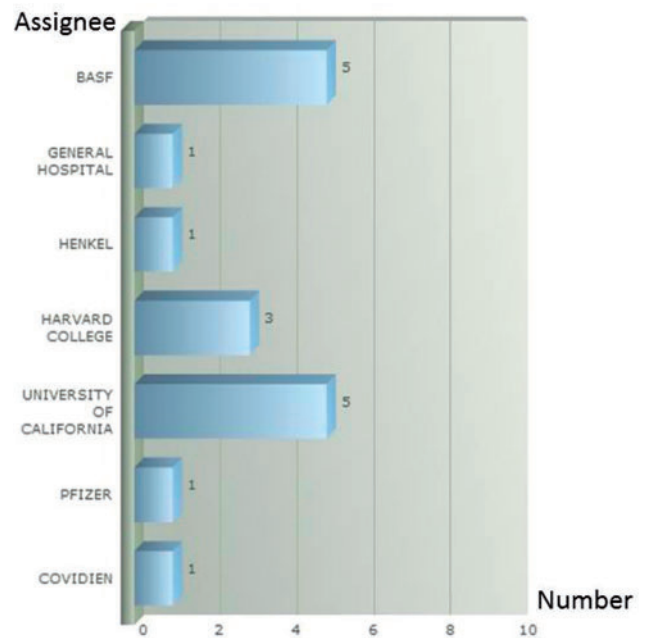


Figure 11. Application frequency of assignees

first patent in 1995. The patent family share (37 patent families) reached the peak in 1999, decreased until another small peak occurred in 2002, and then year by year down its way to zero. HUMAN GENOME SCIENCES started its patent family as early as in 1994. Its patent family share reached the peak with 32 patent families in 2001 and then decreased year by year. GENENTECH started in 1996. Its patent family share reached the peak with 24 patent families in 2006, and after that it decreased year by year. US NIH started early in 1994, but developed steadily. It had 18 patent families in 2009, and then decreased. Considering the mechanism of 20 years duration of patent protection, GENENTECH and NIH are more competitive among these main assignees since the duration of

patents belonging to ZYMOGENETICS and HUMAN GENOME SCIENCES is less than half.

**Analysis of main assignees in technical topics**

1. Clustering analysis of main technical topic
  2. Analysis of main assignees in technical topics
- Among the assignees of ADRIMD, HUMAN GENOME SCIENCES, US NIH, BOSTON SCIENTIFIC SCIME and

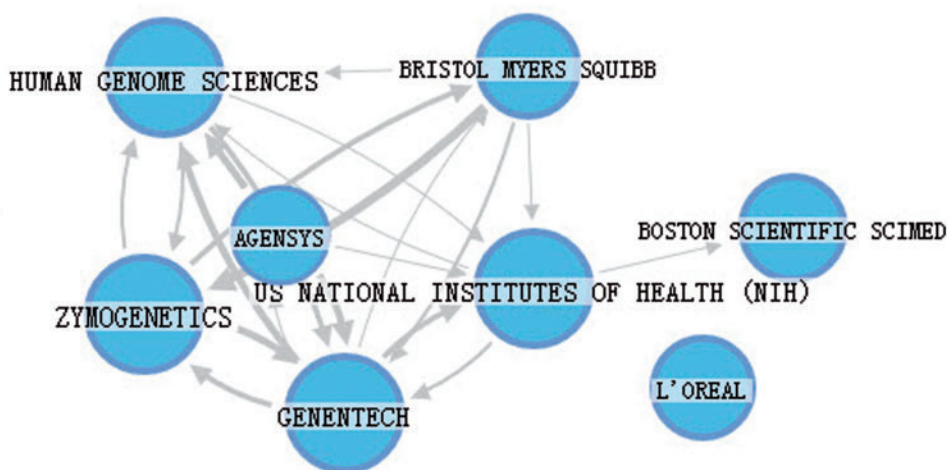


Figure 12. Citation analysis of assignees in the field of ADRIMD

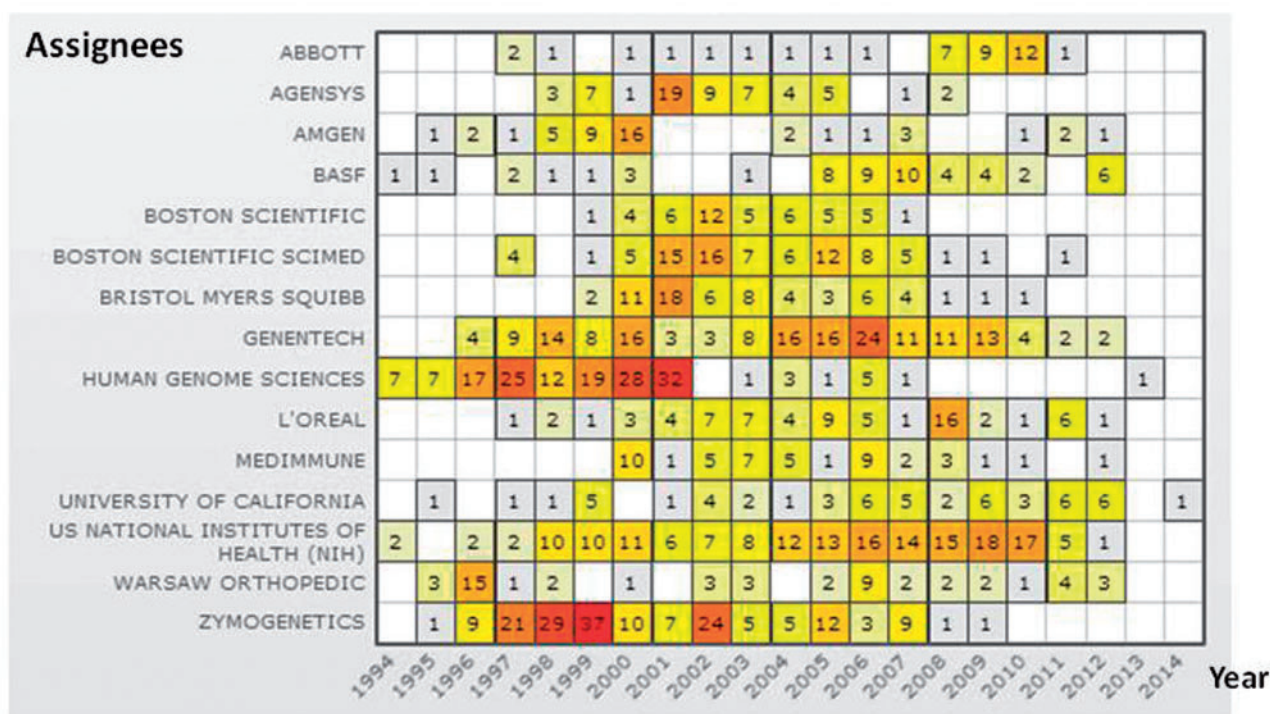


Figure 13. Earliest priority years of main assignees in the field of ADRIMD

UNIVERSITY OF CALIFORNIA focus on broader fields. These assignees mainly focus on the fields of amino acid residue, mucopolysaccharide, nerve stem cell and interactions of AARS polypeptides (Figs 14 and 15).

**Analysis of secondary topics**

Analysis of secondary topics of ADRIMD is shown in Fig. 16

**Analysis of similar patent family share and legal status**

The assignees are ranking in terms of the patent family share (Fig. 17). The legal statuses of its patents are granted and pending. And the most of them are granted patents.

**Summary**

Global scrutiny and analysis of the issue of intellectual property involved in ADRIMD has not occurred at a pace consistent with scientific and industrial progress in the strategic development and deployment of ADRIMD. In regard to the assignees, organizations and companies in the developed countries, such as the United States, Germany, Britain, France, are taking the absolute lead in ADRIMD; however, China (Grandhope) is muscling into the arena due to its enabling policy environment and effort by its scientists although with a narrowed focus comparing with other countries, as far as the assignees ranking in terms of the patent family share is concerned, Grandhope is in the sixth place, and the most of the legal statuses are

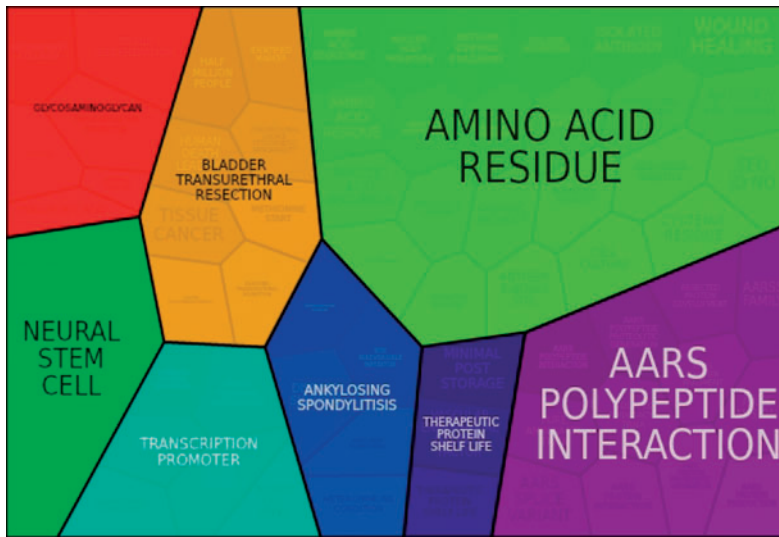
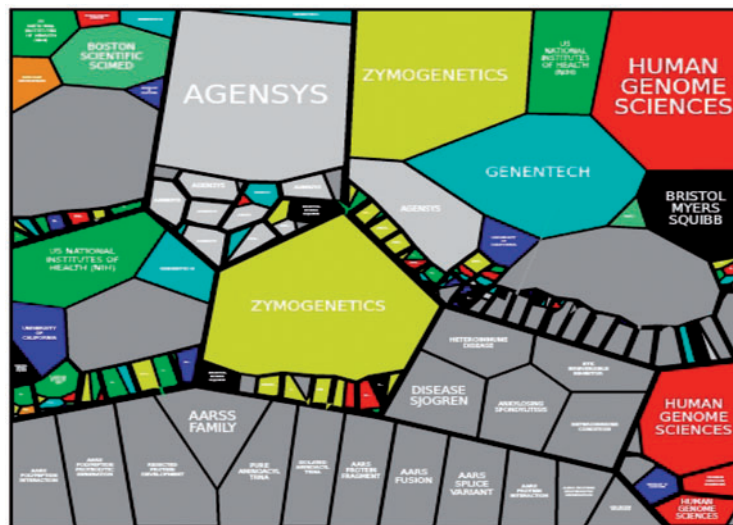


Figure 14. Clustering analysis of main technical topic



ZYMOGENETICS	<span style="color: #90EE90;">■</span>	clustered as①、⑥
US NIH	<span style="color: #008000;">■</span>	clustered as①、③、④
HUMAN GENOME SCIENCES	<span style="color: #FF0000;">■</span>	clustered as①、③、⑥
GENENTECH	<span style="color: #00CED1;">■</span>	clustered as①、④
BOSTON SCIENTIFIC SCIME	<span style="color: #32CD32;">■</span>	clustered as①、③、⑥
WARSAW ORTHOPEDIC	<span style="color: #FF8C00;">■</span>	clustered as③
BRISTOL MYERS SQUIBB	<span style="color: #000000;">■</span>	clustered as①、④
AGENSYS	<span style="color: #FFFFFF;">■</span>	clustered as①、②
UNIVERSITY OF CALIFORNIA	<span style="color: #0000FF;">■</span>	clustered as①、③、④

Figure 15. Technical topic distribution of assignees

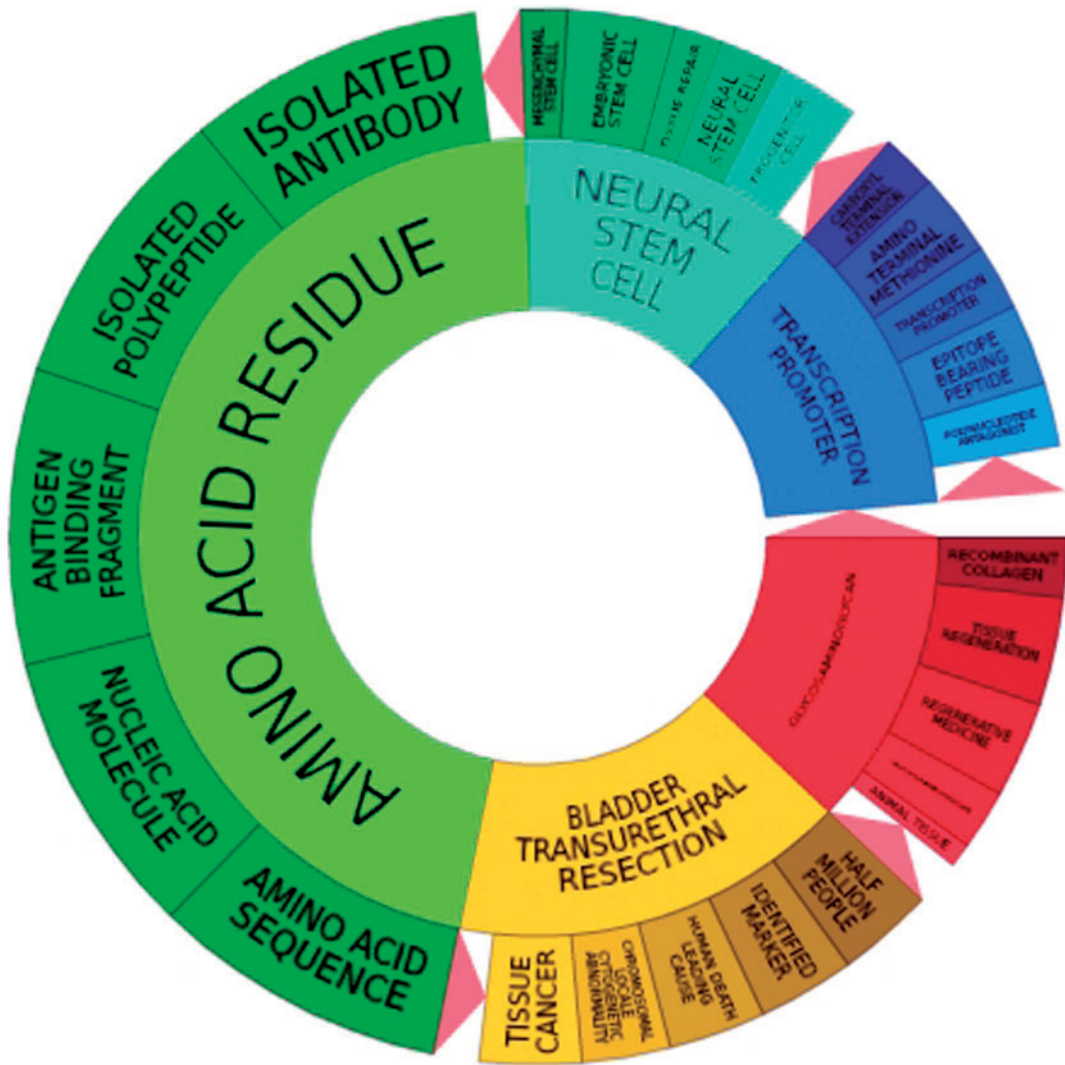


Figure 16. Analysis of secondary topics of ADRIMD

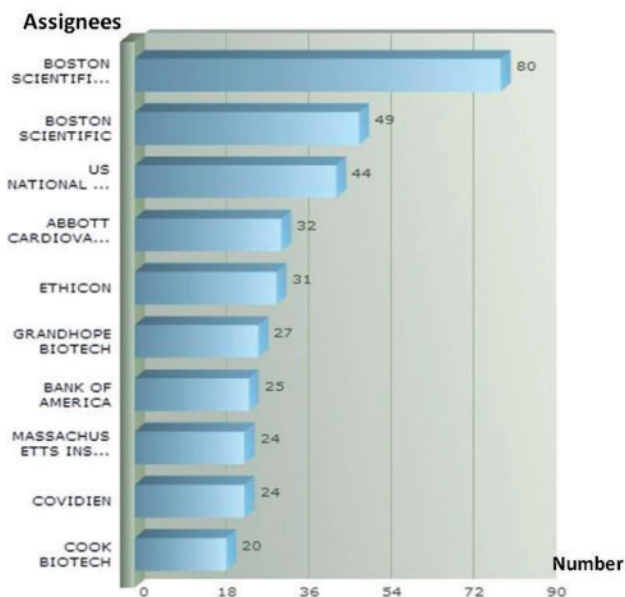


Figure 17. Ranking of similar patent family (Top 10)

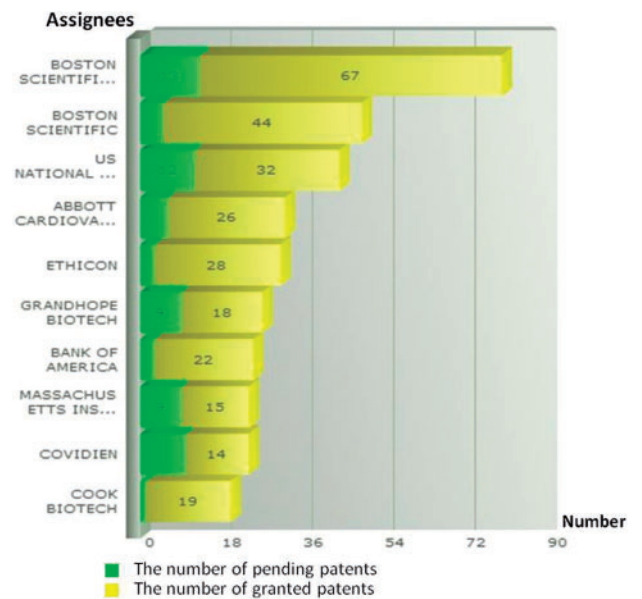


Figure 18. Legal status of similar patent family

granted patents (figs 17 and 18). Governmental agencies, enterprises and colleges and universities as well are involved in this emerging field of medicine. The pipeline of their research and development are clustered around bone regeneration, polycaprolactone, intestinal submucosa, tissue in growth (tissue growth factors). The legal status of ADRIMD patents is dominantly granted. Currently, magnates have occurred in ADRIMD R&D; however, the Mathew effect in ADRIMD should be avoided; after all it is the health of all the humanity at stake. If a deeper look at the disease pattern and disease burden in respective countries and the world would have been made against the three-decade history and current situation of ADRIMD, more interesting and significant insights would have been made.

## Acknowledgements

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*Conflict of interest statement.* None declared.

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