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Chinese Innovation in Regenerative Medicine

Summary

Within Health Sciences, Regenerative Medicine is an area that China excels in. Research mostly happens in universities across the country, but it is to be expected that the Chinese Academy of Sciences will take a bigger share in this research. Patent analyses suggest corporate innovation is still limited compared to other countries. Therefore, Dutch interests in Regenerative Medicine in China would be mainly in research cooperation, mostly because of relaxed rules concerning stem cell research, research funding, and large patient samples.

Full message

With its ideal of curing the patient instead of treating a disease, regenerative medicine is in its philosophy closer to traditional Chinese medicine than other areas of western Medicine. Perhaps this is one of the reasons why the area receives so much attention in Chinese public research. Scientific publications database Scopus reveals that 13% of the world's scientific publications had an affiliation in China is this area from 2012-2015, compared to only 8% overall in Medicine[1]. Next to that, the output also had a staggering annual growth rate of 18%. Enabling technologies like microfluidics, organ-on-a-chip, and lab-on-a-chip (Biochips) also receive similar amounts of attention, with even a world share of 15% and 26% growth. However, the share is still small compared to Engineering or Physical Sciences.

However, research in this area is internationally well recognized. Chinese papers get cited about as much as world average, but this impact rises with 5% every year. Biochips research gets cited even 25% more than world average. Normally research from China is still below world average, especially in Health Sciences. Still, the impact is quite far below the Netherlands. There are at least ten formalized collaborations between China and other countries specifically in the area of Regenerative Medicine, such as between the China Bio-Med Regeneration Technology Limited (CBMRT) and the University of Oxford, which established a 8.8 M EUR joint engineering center[2].

Funding behavior reveals a governmental focus in this area. 22% of publications in this area note funding by the Natural Science Foundation of China (NSFC) and various provincial funding schemes, compared to 16% overall.

Table 1 displays the ten universities with the biggest output in Regenerative Medicine. Biochips is partly included in this research and is too small an area to give meaningful metrics on separately for universities. However, in terms of papers, Tsinghua University, Peking University and Shanghai Jiaotong University have the most activities in this area.

There is relatively little difference in impact and internationality across different universities. Striking is the absence of the Chinese Academy of Sciences (CAS), China's largest government funded research organization. None of the geographic divisions was able to make it into the top 10, but CAS Beijing is still quite prominent in Biochips research. In general CAS is relatively small in Health Sciences. However, in its

[1] To get the right publications, groups of author keywords and journals were selected which shared more than 25% of their appearances with the keywords 'regenerative medicine', 'tissue engineering' or 'cell therapy' for Regenerative Medicine, and with 'microfluidics', 'organ-on-a-chip' or 'lab-on-a-chip' for Biochips. This led to ~20 journals like 'Microfluidics And Nanofluidics', and keywords like 'Tissue Scaffold'. Searching using these journals and terms incorporated about 150,000 publications worldwide, 5 times as much as with the basic keywords alone. Unless otherwise stated, all data in this report are from 2012-2015.

[2] See http://www.eng.ox.ac.uk/about/news/new-technology-centre-with-chinas-regenerative-medicine-industry, and https://burnstrauma.biomedcentral.com/articles/10.1186/s41038-016-0046-8 for the full list of collaborations.

13th five year plan, CAS has a clear focus on Health Sciences, with 8 of its 60 main projects in this area. Of these, Organ Repair and Reconstruction is one of the clearly defined projects. The aim is "To achieve tissue regeneration, organ repair, organ remodeling and replacement, to answer fundamental scientific questions regarding cell potency and fate, for diseases in the nerve, cardiovascular, digestive, reproductive and metabolic system." Furthermore, there are two other related projects, namely "Cell Fate and Aging", and "High-performance Material Design", of which biomedical materials are a focus. It is to be expected that the Chinese Academy of Sciences, with its abundant resources, will play a much bigger part in Regenerative Medicine research in the future.

Companies	Scientific Publications	Countries per Publication	Citation Impact[3]	Industry Papers (%)	Granted Patents[4]
China	20452	1.31	0.96	3.6%	7733
Shanghai Jiaotong University	1271	1.34	1	2.6%	64
Peking University	892	1.27	1.11	2.1%	46
Sichuan University	813	1.31	0.93	1.9%	59
Zhejiang University	808	1.36	1.02	2.5%	116
Sun Yat-Sen University	673	1.33	0.84	2.5%	34
Soochow University	571	1.31	1.1	2.5%	51
Fudan University	555	1.29	1.14	2.7%	40
Huazhong University of S&T	524	1.38	1.12	2.5%	11
Tsinghua University	495	1.41	1.41	1.2%	89
Southern Medical University	483	1.2	0.88	4.4%	24

Table 1: Top 10 biggest research institutes and universities based on number of scientific publications produced. Period from 2012-2015.

The number of innovative companies active in this field is still limited. In contrast to other research areas, biggest patent holders are all universities. All together the Chinese jurisdiction takes up less than 60% of the world share of patents it has in general in the Medical Science category. Another sign is the low percentage of publications shared with industry compared to world average (4.2%). Combining affiliations on scientific publications and patents, a few companies pop up, most notably Medprin Regenerative Medical Technologies (Guangzhou). There are a greater number of companies active in innovative implants, like Nantong Bubbfil Nanotechnology, using innovative nanofibers for implants. Important is also Jiangsu Beike, the world's largest stem cell provider. Foreign players have a relatively high share among companies filing in China.

Rules concerning stem cell research are quite relaxed in China. In fact, the rules had been so relaxed before, that many rogue clinics offering unproven stem cell treatments sprung up around the country. Since 2015 a draft set of more strict rules have been put in place, but with little ethical or religious objections from the Chinese people, more is possible than in most other countries. The new rules also promise greater compatibility with international standards, although it remains to be seen how it will work out in practice[5].

Funding behavior, the 13th five year plans of China's most important research organization, and reform of stem cell rules suggest that Regenerative Medicine is a focus area of the Chinese government within Health Sciences. The field is one of the best in terms of impact and internationality within Chinese research, but corporate innovation activity is still limited, highlighted by low numbers of patent filings and publications shared with industry. Most chances for the Netherlands thus lie in research cooperation, with one of the universities in table 1, or an institute of the Chinese Academy of Sciences, such as the Guangzhou Institute of Biomedicine and Health.

[3] Parameters used in the "mean normalized citation score", the number of citations per paper normalized by the world average per year. A score of 1.00 means cited exactly average for the world, less means cited less. Only English language articles and reviews were used for this.

[4] Categories used were: A61L27, C12N5, and C12M3.

[5] For more information, see http://www.futuremedicine.com/doi/pdf/10.2217/rme.15.80