

Scientometric Evaluation of Highly Cited Papers in the Field of Biotechnology (2001-2020)



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ABSTRACT: The aim of this paper was to identify and analyse the most highly cited research articles, and authorships levels in the discipline of biotechnology during the year of 2001-2020 by using the Web of Science database. The analysis of most cited papers in the chosen areas of research domain will enable the researcher to identify a wide set of inferences about the research area - its productivity over Annual production, page length, Most prolific authors, Most cited Countries, Most relevant affiliations of the articles etc. The results shows that a total of 3000 research articles were published during 2001-2020 in the field of biotechnology. The most highly cited research articles were 1434, followed by 1337 review papers. 12983 papers used the term 'biotechnology' as keywords. The average publication of highly cited paper were 150 papers per year. Furthermore, out of 12347 research articles, 340 research articles were published in single authorship, while 12007 were published in collaborative authorship. Apparently, the highest numbers ($n=230$, 7.6%) of papers were published in 2007. In terms of research output, the most productive research institutes in the field of biotechnology were 'University of Calif Berkely', while the most productive countries were USA and Germany. Pruitt KD and Ostell J. were the most prominent and influential authors in the field of biotechnology.

Keywords: Biotechnology, Author Productivities, Biotechnology Research, Scientometric

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1. Introduction

This paper analyses a scientometric evaluation of highly cited articles in the field Biotechnology.

Scientmetric-Scientometric is the quantitative investigation of the disciplines of science-dependent on distributed writing and correspondence. It is quite possibly the main measures for the evaluation of logical production. According to Van Raan "Scientometric research is devoted to quantitative studies of science and technology" (Van Raan, 1997).

Biotechnology-Biotechnology is a blend of science and advancement. This Technology is used for finding some ailment, allevi-

ating methodologies for that disorder, and that diseases Come from which Microbes, Pathogens, or Gems. In current days biotechnology is used for changing, Modifying Genetic structure in animals and plants to additionally foster them in an optimal way for getting invaluable things.

To achieve the target objectives, several e-databases were consulted including Research Gate, Science Direct, Web of Science and google scholar. Truncated search term and keyword search strategies were used to retrieve data on “biotechnology”. The study was limited to articles written/published in English language only. Similarly, a quantitative approach and Zotero, software was used to analyse the data.

2. Objectives

To conduct basic metric analyses on highly cited papers of Annual global Biotechnology research Productivity

To find out the page length of most cited papers

To know the most prolific authors(>9papers)

To trace out the country-wise research output, most cited countries.

To explore the most relevant affiliations

3. Review of Literature

Zeo-Sánchez, Sánchez-Núñez, Stephens and Lucena (2021) conducted a study on Mass cytometry (CyTOF) research output during 2010-2019. 937 articles were retrieved from the Web of Science database. The study found these 937 papers retrieved a sum of 25801 times cited, making an average of 27.54 citations per paper. The h-index was 71. Of these, 56 were original articles, 14 were reviews and 1 was a book chapter. The peak number of HCPs occurred in 2016, with 17 HCP published. Nature Biotechnology with 9 HCPs was the most productive journal, followed by Cell and Cytometry Part A with 8 and 5 HCPs respectively. Nolan GP ranked highest with 23 HCPs followed by Bendall SC (14 HCPs) and Newell EW (12 HCPs). Nolan GP was also one of the authors with the earliest date of first publication and the highest number of total citations (6531). The affiliations of these authors (75%) corresponded mainly to American hospitals, research centres and universities. The most productive institution was Stanford University (USA) with 172 registered affiliations in HCPs. **Anandhi (2020)** performed a scientometric analysis of research output in India in the field of Green Revolution during the period 2001-2017. 568 records data were accessed from SCOPUS Database. The study reveals that Tiwari, G.N published highest number of papers (21, 3.70%). Document-wise distribution shows that the most number of documents are articles (395, 69.54%). Foreign Countries Contribution in India shows that The United States of America (USA) has the top rate of involvement with 60 (31.91%) in India. The Indian Institute of Technology, Delhi has made the maximum number of publications (36, 25.53%) followed by Indian Agricultural Research Institute with 23 (16.31%) publications. The study concluded that proper planning and intensive collaborative research work should be initiated by the stakeholders for the conservation of the traditional varieties and the inclusion of these varieties and practices into the food and nutrition security plans for the nation owing to their nutritional benefits. **Yeung and Ho (2019)** conducted a study on dentistry during 1990-2000. 3666 records were retrieved from Web of Science. The study reveals that major contributing countries were the USA, Sweden, the UK, and Switzerland. The highly cited articles were written by 3.7 authors on average. Jan Lindhe had the largest number of highly cited articles, whereas David H. Pashley had the highest potential to publish highly cited articles in dentistry. Highly cited articles were distributed among various dental specialties, and the most productive periods were the late 1990s and the early 2000s. The study concluded that highly cited articles were distributed among various dental specialties, and the most productive periods were the late 1990s and the early 2000s. The Y-index gave dimensional details of the prolific authors. **Zhang, Estoque, Xie, Murayama and Ranagalage (2019)** carried out a scientometric study involving highly cited articles on ecosystem services during 1981-2017. The study revealed that 132 highly cited articles were published between 2005 and 2014 from the SCI-E and SSCI databases of the Web of Science. The study revealed that the top three journals in terms of total number of highly cited articles published were Ecological Economics, PNAS, and Ecological Indicators. Despite ranking sixth overall, Science ranked first in both impact factor and total citations per article. Stanford University is associated with many scholars in the field of ecosystem services research because of the InVEST model. Regulating and provisioning services were the major ecosystem services studied. Quantitative and qualitative assessments were the main research focus. Most of these highly cited studies on ecosystem services are done on areas geographically located in North America and Europe. **Zhang, Estoque, Xie, Murayama and Ranagalage (2018)** aimed a

bibliometric analysis on Highly Cited articles on Ecosystem services during 1981- 2017. The analysis revealed that there were 132 highly cited articles, most of which were published between 2005 and 2014. Based on author keywords, the term ecosystem services was strongly linked to biodiversity. The top three journals in terms of total number of highly cited articles published were *Ecological Economics*, *PNAS*, and *Ecological Indicators*. Despite ranking sixth overall, *Science* ranked first in both impact factor and total citations per article. The US, UK, Netherlands, Spain, and Sweden were the top five most productive and cooperative countries in the world based on total number of highly cited articles and co-authorship network, respectively. The US was highly connected to Canada, the Netherlands, China and the UK. Stockholm University and Stanford University were the most productive institutions in Europe and North America, respectively. Stanford University is associated with many scholars in the field of ecosystem services research because of the InVEST model. Robert Costanza was the most prolific and highly cited author, the latter being largely due to the first valuation of the world's ecosystem services and natural capital, he and his co-authors published in 1997 in *Nature*. Terrestrial, urban, and forest ecosystems were the top types of ecosystems assessed. Regulating and provisioning services were the major ecosystem services studied. Quantitative and qualitative assessments were the main research focus. Most of these highly cited studies on ecosystem services are done on areas geographically located in North America and Europe. **Zhang, Huang and Du (2016)** conducted a study on the top-cited systematic reviews/meta-analyses in tuberculosis during 1997-2014. The Web of Science Core Collection was the source. The study reveals that the 100 top-cited studies were cited from 54 to 662 times and were published between 1997 and 2014. Ten authors have more than 1 study as the first author and 10 authors have more than 1 study as corresponding author. The country with the most top-cited studies was USA (n=26). The institutions with the largest number of the studies were McGill University in Canada (n=18). The studies were published in 32 journals, whereas 12 were published in PloS Medicine, followed by Lancet Infectious Diseases (n=11). The study concluded that developed countries and high-impact journals may publish more top-cited systematic review/meta-analysis in tuberculosis research. **Karpagam (2014)** performed a scientometric analysis on global research output of Nanobiotechnology Research during 2003–2012. Totally 114,684 papers were published during 10 years, which received 2,503,795 citations with an average of 21.83 citations per paper. It has been observed that during 2003–2012, USA held the first position by number of publications (34,736), h-index (349), g-index (541), hg-index (434.52) and p-index (326.47). Developing countries such as India, China, South Korea and Canada showed increasing trends in their publications and their activity index also showed increasing trends. Top 10 institutions contributed 7.16% share of total publications. Massachusetts Institute of Technology, USA received the highest h-index (120) among the top 10 institutions. Bio-materials (1631) was the top journal of publication output; Nano Letters had the highest impact with an average citation per paper (73.86) and American Chemical Society received the highest h-index (158) among the top 10 journals. The study concluded that transparency and public involvement in the design and implementation of regulatory structure in nanobiotechnology should be ensured. **Mallik and Mandal (2014)** carried out a bibliometric analysis of global publication output and collaboration structure in microRNA during 2002-2012. Totally 14,000 documents were retrieved from Web of Science. The study has observed that number of publications increased from 8 in 2002 to 4,186 in 2012 with compound annual growth rate of 87 %. The compound annual growth rates of countries, institutions, number of journals, research areas, and authors are 36.60, 76.64, 64.80, 30.5, and 88.09 % respectively. The study concluded that research linkages of different countries, organizations and authors would be helpful in strengthening the existing linkages and to promote new linkages for knowledge development in the microRNA research. **Tao (2012)** conducted a bibliometric study to identify and characterize the most highly cited clinical research articles published on SEPSIS during 1974-2008. Totally of 2,151 articles were gathered from Web of Science. The analysis found that a total of 2,151 articles were cited more than 100 times; the 50 top-cited clinical articles were published between 1974 and 2008. The number of citations ranged from 372 to 2,932, with a mean of 678 citations per article. These citation classics came from nine countries, of which 26 articles came from the United States. Articles originating from the United States and published in high-impact journals are most likely to be cited in the field of sepsis research. **Ioannidis (2006)** conducted a scientometric study on Journal 'Ecosystems'. 100 most cited records were accessed from 21 scientific areas. The study reveals that only 9% of journals in Journal Citation Reports had published at least one such paper. Among this 9%, half of them had published only one such paper. The number of journals that had published a larger number of most-cited papers decreased exponentially according to a Lotka law. Except for three scientific fields, six journals accounted for 53 to 94 of the 100 most-cited papers in their field. With increasing average number of citations per paper (citation density) in a scientific field, concentration of the most-cited papers in a few journals became even more prominent ($p = 0.001$). Concentration was unrelated to the number of papers published or number of journals available in a scientific field. Amidst a plethora of available journals, the most influential papers are extremely concentrated in few journals, especially in fields with high citation density. Existing multidisciplinary journals publish selectively most-cited papers from fields with high citation density.

4. Materials and Methods

• **Source:** Web Of Science

- Scope : with 3000 articles (All are in English Language)
- Duration : 2001-2020
- Software used for Data analysis :Zotera and MS Excel
- Technique : Normal count procedure

| S.No | Year | Articles | % | Cum. Total | Cum. % |
|------|------|----------|------|------------|--------|
| 1 | 2001 | 142 | 4.43 | 142 | 4.73 |
| 2 | 2002 | 137 | 4.56 | 279 | 9.30 |
| 3 | 2003 | 167 | 5.56 | 304 | 14.87 |
| 4 | 2004 | 195 | 6.05 | 362 | 21.37 |
| 5 | 2005 | 199 | 6.63 | 394 | 28.00 |
| 6 | 2006 | 193 | 6.43 | 392 | 34.43 |
| 7 | 2007 | 230 | 7.66 | 423 | 42.10 |
| 8 | 2008 | 185 | 6.16 | 415 | 48.27 |
| 9 | 2009 | 216 | 7.20 | 401 | 55.47 |
| 10 | 2010 | 226 | 7.53 | 442 | 63.00 |
| 11 | 2011 | 228 | 7.60 | 454 | 70.60 |
| 12 | 2012 | 190 | 6.33 | 418 | 76.93 |
| 13 | 2013 | 171 | 5.70 | 361 | 82.63 |
| 14 | 2014 | 173 | 5.76 | 344 | 88.40 |
| 15 | 2015 | 146 | 4.86 | 319 | 93.27 |
| 16 | 2016 | 99 | 3.30 | 245 | 96.57 |
| 17 | 2017 | 42 | 1.40 | 141 | 97.97 |
| 18 | 2018 | 37 | 1.23 | 79 | 99.20 |
| 19 | 2019 | 21 | 0.70 | 58 | 99.90 |
| 20 | 2020 | 3 | 0.10 | 24 | 100.00 |

Table 1. Annual Production: Bio-technology Research Output

Table 4.1 shows the year-wise analysis of highly cited papers in Biotechnology research output during 2001-2020. The Research output shows a gradual growth from 2001 to 2020. The average publication per year was 150. The highest numbers records 230(7.6%) were published in the year 2007 followed by 228(7.6%) records in 2011 and 226(7.6%) in 2010 and so on. The least number of records i.e 3(0.1%) were published in the year 2020.

The Cumulative analysis shows that first ten years of the study period i.e 2001 to 2010 had contributed 1890(63%) of highly cited papers in Biotechnology research output and the remaining ten years i.e 2011-2020 had contributed the rest of the publications 1110(37%).

| S.No | Page Number Range | Number of Documents |
|--------------|-------------------|---------------------|
| 1 | 01 – 10 | 1334 |
| 2 | 11 – 15 | 787 |
| 3 | 16 – 20 | 384 |
| 4 | 21 – 25 | 209 |
| 5 | 26 – 30 | 108 |
| 6 | 31 – 60 | 160 |
| 7 | 61 – 90 | 13 |
| 8 | 91 – 120 | 3 |
| 9 | 121 – 150 | 1 |
| 10 | 151 – 180 | 1 |
| Total | | 3000 |

Table 2. Page Length

Table 2 and Figure 1 show the page length of the highly cited papers in Biotechnology research output 2001-2020.

A high majority of highly cited papers (1334) have 1-10 pages while 787 papers have 11-15 pages and 384 papers have 16-20 pages. While 209 papers have 21-25 pages, 160 papers have 31-60 pages and 108 papers have 26-30 pages. Only 13 papers have 61-90 pages while one document each contains 121-150 and 151-180 pages. Thus, most of the highly cited papers in biotechnology have 1-30 pages.

Table 3 shows the most prolific authors of highly cited papers of biotechnology research output 2001-2020.

Pruitt KD is the most productive author with 24 (1.66) highly cited papers followed by Ostell J with 22 (1.33) papers and Madden TL with 21 papers (1.14). They are followed by Maglott DR with 19 papers and Barrett Tand Nielsen J with 18 papers each and Schuler GD and Tatusova TA with 17 papers. While Benson DA and Sherry ST have published 16 papers, Bryant SH, Diuccio M, Federhen S and Sayers EW have published 15 highly cited papers each. There are five authors who have contributed 14 papers each and there are 4 authors with 13 papers each. 3 authors have published 12 papers each while 5 authors have published 11 papers each and 2 authors have published 10 papers each.

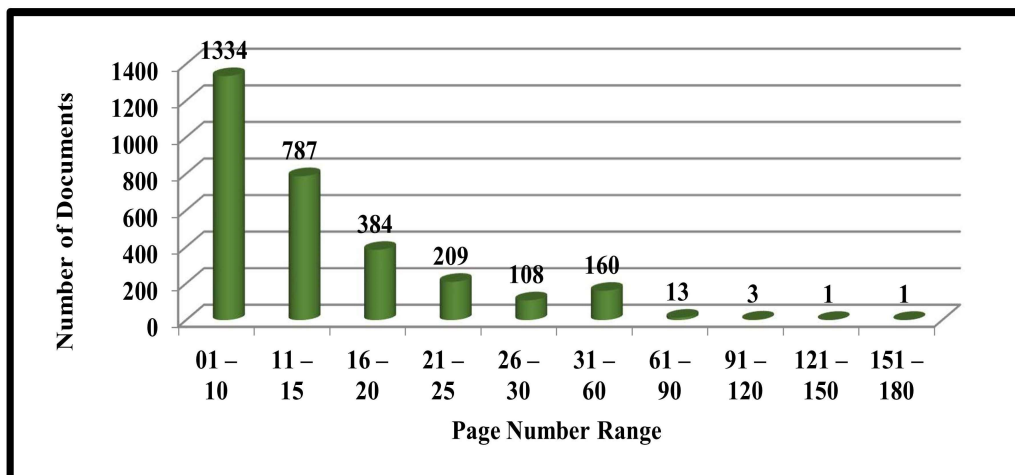


Figure.1. Page Length

| S.No | Authors Articles | Articles | Fractionalized |
|------|------------------|----------|----------------|
| 1 | Pruitt KD | 24 | 1.66 |
| 2 | Ostell J | 22 | 1.33 |
| 3 | Madden TL | 21 | 1.14 |
| 4 | Maglott DR | 19 | 1.24 |
| 5 | Barrett T | 18 | 1.15 |
| 6 | Nielsen J | 18 | 6.43 |
| 7 | Schuler GD | 17 | 0.66 |
| 8 | Tatusova TA | 17 | 0.66 |
| 9 | Benson DA | 16 | 0.82 |
| 10 | Sherry ST | 16 | 0.61 |
| 11 | Bryant SH | 15 | 0.52 |
| 12 | Dicuccio M | 15 | 0.38 |
| 13 | Federhen S | 15 | 0.47 |
| 14 | Sayers EW | 15 | 0.84 |
| 15 | Canese K | 14 | 0.38 |
| 16 | Church DM | 14 | 0.61 |

| | | | |
|----|------------------|----|------|
| 17 | Lipman DJ | 14 | 0.66 |
| 18 | Sirotkin K | 14 | 0.47 |
| 19 | Yaschenko E | 14 | 0.34 |
| 20 | Geer LY | 13 | 0.32 |
| 21 | Rothaermel FT | 13 | 7.50 |
| 22 | Starchenko G | 13 | 0.31 |
| 23 | Wagner L | 13 | 0.59 |
| 24 | Feolo M | 12 | 0.37 |
| 25 | Phan L | 12 | 0.51 |
| 26 | Sequeira E | 12 | 0.43 |
| 27 | Bock R | 11 | 5.94 |
| 28 | Landsman D | 11 | 0.24 |
| 29 | Lu ZY | 11 | 1.23 |
| 30 | Wang YL | 11 | 0.74 |
| 31 | Zhang Y | 11 | 2.08 |
| 32 | Edgar R | 10 | 1.01 |
| 33 | Marchler-Bauer A | 10 | 0.24 |

Table 3. Most prolific authors (>9 papers)

| S.No | Country | Total Citations | Average Article Citations |
|------|----------------|-----------------|---------------------------|
| 1 | USA | 257395 | 258 |
| 2 | United Kingdom | 53151 | 243 |
| 3 | Germany | 52716 | 201 |
| 4 | China | 44738 | 225 |
| 5 | India | 20907 | 188 |
| 6 | Netherlands | 19268 | 229 |
| 7 | France | 17599 | 207 |
| 8 | Japan | 16477 | 172 |
| 9 | Australia | 16243 | 220 |

| | | | |
|----|----------------|-------|-----|
| 10 | Spain | 16112 | 170 |
| 11 | Italy | 13893 | 183 |
| 12 | Canada | 13301 | 171 |
| 13 | Korea | 10174 | 208 |
| 14 | Sweden | 7609 | 159 |
| 15 | Belgium | 7590 | 217 |
| 16 | Denmark | 7440 | 169 |
| 17 | Switzerland | 7131 | 152 |
| 18 | Austria | 6759 | 241 |
| 19 | Brazil | 4975 | 178 |
| 20 | Israel | 4807 | 218 |
| 21 | Singapore | 4522 | 188 |
| 22 | Greece | 3915 | 170 |
| 23 | Portugal | 3323 | 144 |
| 24 | Czech Republic | 3235 | 231 |
| 25 | Russia | 2869 | 169 |
| 26 | Poland | 2638 | 176 |
| 27 | South Africa | 2530 | 169 |
| 28 | Ireland | 2458 | 145 |
| 29 | Malaysia | 2362 | 215 |
| 30 | Norway | 2028 | 203 |
| 31 | Iran | 2016 | 119 |
| 32 | Saudi Arabia | 2014 | 201 |
| 33 | Turkey | 2007 | 134 |
| 34 | Finland | 1913 | 128 |
| 35 | Mexico | 1662 | 119 |
| 36 | New Zealand | 1565 | 156 |
| 37 | Thailand | 1008 | 144 |
| 38 | Slovakia | 843 | 211 |
| 39 | Slovenia | 756 | 151 |
| 40 | Hungary | 713 | 178 |
| 41 | Philippines | 698 | 349 |
| 42 | Pakistan | 599 | 120 |
| 43 | Argentina | 563 | 141 |
| 44 | Azerbaijan | 436 | 436 |

| | | | |
|----|-----------------|-----|-----|
| 45 | Romania | 375 | 375 |
| 46 | Nigeria | 373 | 124 |
| 47 | Egypt | 329 | 110 |
| 48 | Chile | 325 | 108 |
| 49 | Oman | 312 | 156 |
| 50 | Kazakhstan | 274 | 274 |
| 51 | Lithuania | 221 | 221 |
| 52 | Bulgaria | 202 | 101 |
| 53 | Kenya | 136 | 136 |
| 54 | Luxembourg | 131 | 131 |
| 55 | Estonia | 123 | 123 |
| 56 | Morocco | 112 | 112 |
| 57 | U Arab Emirates | 112 | 112 |
| 58 | Ukraine | 111 | 111 |
| 59 | Bangladesh | 97 | 97 |
| 60 | Serbia | 88 | 88 |
| 61 | Tunisia | 87 | 87 |
| 62 | Belarus | 75 | 75 |

Table 4. Shows the most cited countries in the highly cited research output of Biotechnology 2001-2020

The country with par excellence is USA, which have obtained 257395 citations followed by UK with 52716 citations, Germanywith 52716 citations, China with 44738 citations and India with 2090 citations. The countries which have obtained a citation score of 10000-20000 include Netherlands (19268), France (17599), Japan (16477), Australia (16243), Spain (16112), Italy (13893), Canada (13301) and Korea (10174). Five countries namely Sweden, Belgium, Denmark, Switzerland and Austria have obtained more than 5000 but less than 8000 citations while there are 15 countries that have secured 2000-5000 citations. Four countries have got 1000-2000 citations while the remaining 25 countries have received 75-850 citations.

When the average article citation count is considered, the countries like Azerbaijan (436), Romania (375), Phillipines (349) and Kazakhstan (274) topped the table, as they have published just one or two papers, but received more citations. USA has achieved the average article citation score of 258 followed by UK (243), Austria (241), Czech Republic (231), Netherlands (229), China (225) and Lithuania (221). 10 countries have obtained the average article citation score of 200-220 while all other countries except Bangladesh, Serbia, Tunisia and Belarus, have obtained an average article citation score of 101-200.

Table 4.5 showsthe most relevant affiliations in respect of 3000 highly cited papers in Biotechnology research output 2001-2020. The most vibrant research institutes in the field of biotechnology include ‘University OfCalifBerkely’ (68 papers) followed by ‘University ofHarvad’ (64), ‘NatlCtrBiotechnol Informat’ (55), ‘Duke Univ.’ (50), ‘UnivCalif San Diego’ (50) and ‘Univ Michigan’ (50). These 7 institutions alone have contributed 10% of total highly cited papers.

While 45 papers were published by ‘Univ Illinois’, 44 papers were published by Boston Univ and UnivCalif Los Angeles. Stanford University has published 41 papers. 11 institutions have published 30-40 highly cited papers in biotechnology while 8 institutions have published 25-29 highly cited papers.

| S.No | Affiliations | Articles |
|------|--|----------|
| 1 | UnivCalif Berkeley | 68 |
| 2 | Harvard Univ | 64 |
| 3 | NatlCtrBiotechnolInformat | 55 |
| 4 | Duke Univ | 50 |
| 5 | UnivCalif San Diego | 50 |
| 6 | Univ Michigan | 50 |
| 7 | Univ Illinois | 45 |
| 8 | Boston Univ | 44 |
| 9 | UnivCalif Los Angeles | 44 |
| 10 | Stanford Univ | 41 |
| 11 | Tech Univ Denmark | 39 |
| 12 | Cornell Univ | 37 |
| 13 | Univ Florida | 37 |
| 14 | Univ Toronto | 36 |
| 15 | Univ Wisconsin | 36 |
| 16 | Northwestern Univ | 35 |
| 17 | Univ Washington | 35 |
| 18 | Univ Cambridge | 33 |
| 19 | Univ Maryland | 33 |
| 20 | Johns Hopkins Univ | 31 |
| 21 | UnivCalif Davis | 31 |
| 22 | UnivCalif Santa Barbara | 30 |
| 23 | Univ Tokyo | 30 |
| 24 | NatlUniv Singapore | 29 |
| 25 | Purdue Univ | 27 |
| 26 | Univ London Imperial CollSci Technol and Med | 27 |
| 27 | Penn State Univ | 25 |
| 28 | Seoul NatlUniv | 25 |
| 29 | Univ Manchester | 25 |
| 30 | Univ Minnesota | 25 |
| 31 | Univ Texas | 25 |

Table 5. Most relevant affiliations

5. Conclusion

This study reveals that research on biotechnology is a flourishing and influential field. Though, it is suggesting that research at individual level, institutional level and collaborative research efforts and resource sharing should be encouraged. Research incentives, project grants and paper awards etc. should be promoted to facilitate research activities. Furthermore, publications in open access journals should supported to overcome access to online journals.

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