

# Global Collaborative Patterns on Bioelectronics Research Output

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## Abstract

The collaborative research or team research is predominant among science disciplines. The reason may be that the need for the culmination or fusion of subjects in one angle as well as the need for excellent research infrastructure. This has been proved by this study as most of the authors of different countries collaborated with US authors. Interestingly this study also focus the research talents of India on the subject under study as well as the collaborative patterns of India authors as such mostly they are teaming with US authors, Japan and south Korean authors.

**Keywords:** Authorship Pattern; Global Collaborative Pattern; Bioelectronics Research Out; Scientometrics.

## Introduction

The collaborative research is an inevitable phenomena in all the disciplines, especially it is more in Science and technology disciplines rather than humanities and social sciences. The collaborative pattern is one basic component of scientometric research and paved the ways to understand the magnitudes of the collaborative research pattern of the team research in a particular discipline. Thus, this research paper is through the light on the team research of the subject bioelectronics.

### Review of Literature

Dutt, Bharvi and Nikam studied collaboration in solar cell research in India as reflected by the publications indexed in Web of Science for a period of 20 years from 1991-2010. Almost half of the total output emerged out of domestic and international collaboration. Elango, B and Rajendran, P examined authorship trend and collaboration pattern in Marine Sciences literature. For this purpose, the required data has been collected from the Indian Journal of Marine Sciences published from 2001 to 2010. Liang, Liming ; Guo, Yongzheng and Davis, Mari studied on age

structure of scientific collaboration in Chinese computer science. Based on an extended database a new method is used to analyze the nature and preference of collaboration. Observed values of two-three- and four-dimensional collaboration were compared respectively with their expected values. Anuradha, K. T. and Shalini R. studied International collaboration is becoming an increasingly significant issue in science. During the last few years, a large number of bibliometric studies of co-authorships have been reported. Mostly, these studies have concentrated on country-to-country collaboration, revealing general patterns of interaction. In this study we analyze international collaborative patterns as indicated in the Indian publications by tracking out multi author publications as given in Science Citation Index (SCI) database. Correspondence analysis is used for analysis and interpretation of the results. Kaliyaperumal, and Natarajan. (2009) studied the growth pattern as well as overall trend in literature output on retina during 2002-2007 along with the collaborative pattern of the authors. The contribution of the US is higher in this subject when compared to other countries.

### Bioelectronics : an Overview

The first reference to bioelectronics, published in 1912, focused on measurement of electrical signals generated by the body, which is the basis of the electrocardiogram. In the 1960s two new trends in bioelectronics began to appear. One trend, enabled by the invention of the transistor, centered on the development of implantable electronic devices and

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systems to stimulate organs, e.g., the pacemaker. In the same time frame, fundamental studies were beginning to be reported on electron transfer in electrochemical reactions. Today, these three areas of endeavor are converging to enable multi-signal recording and stimulation at the cell level, i.e., there is a kind of physical scaling law that is moving over time from the organ level toward cellular dimensions. At the same time, studies at the molecular level are leading to new understanding of cell performance. The analogy with nanoelectronics is striking; top-down scaling is being abetted by device design from the atomic level.

#### *Objectives of the Study*

- To analyse the global collaboration index over a period of 26 years starting from 1989 to 2014.
- To illustrate the international collaborations of the authors among the top ranking countries in terms bioelectronics output

- To identify International collaboration pattern exist among different regions and countries

#### **Research Methodology**

For the purpose of the study an amount of 56561 records on bioelectronics are down loaded from Scopus database with various bibliographical indicators. However, as per the aims of this study the collaborative pattern of the research output alone is taken into account for the study. Thus, SPSS has been used for further analysis and presentation of data for the easy interpretations, but wherever deemed to be fit suitable diagrams are drawn to illustrate the collaborative pattern of the research output.

#### *Data Analysis and Interpretation*

Collaboration index is a bibliometric indicator that represents the number of authors per paper in team

**Table 1:** Collaboration index over a period of 26 years

S.No.	Year	No of Authors	No of Publications	Global Collaborative Index
1	1989	217	122	1.78
2	1990	307	154	1.99
3	1991	682	365	1.87
4	1992	753	398	1.89
5	1993	992	534	1.86
6	1994	1310	609	2.15
7	1995	1656	772	2.15
8	1996	1841	870	2.12
9	1997	2119	945	2.24
10	1998	2643	1088	2.43
11	1999	2699	1145	2.36
12	2000	3225	1348	2.39
13	2001	3371	1408	2.39
14	2002	3902	1566	2.49
15	2003	4580	1735	2.64
16	2004	5002	1949	2.57
17	2005	6023	2301	2.62
18	2006	7090	2670	2.66
19	2007	8336	3143	2.65
20	2008	9462	3558	2.66
21	2009	9909	4080	2.43
22	2010	10080	4030	2.50
23	2011	13528	5221	2.59
24	2012	14363	5042	2.85
25	2013	16580	5648	2.94
26	2014	16229	5860	2.77
			56561	<b>2.38</b>

**Table 2:** International Collaboration of Authors

S.No..	Countries	Total no. of Publications	Percent
1	USA	6982	52.40
2	China	804	6.03
3	Japan	409	3.07
4	South Korea	400	3.00
5	Italy	354	2.66
6	Sweden	336	2.52
7	Spain	324	2.43
8	England	306	2.30

9	Taiwan	193	1.45
10	India	148	1.11
11	Canada	143	1.07
12	Iran	134	1.01
13	Brazil	131	0.98
14	Russia	127	0.95
15	Hong Kong	123	0.92
16	Switzerland	122	0.92
17	Ireland	110	0.83
18	Australia	108	0.81
19	Oman	106	0.80

research. From the Table 1, it is found that the collaboration index ranges from 1.78 in the year 1989 to 2.94 in 2013 and 2.77 in the year 2014. The average collaboration index works out to 2.33. This means that the average number of authors in team research in Bioelectronics is 2 to 3.

#### *International Collaboration*

The total publications taken for study are 56561 which comprise of solo research as well as collaborative or team research. There are 53296 collaborative publications which of which 13325 papers are the results of international collaboration. Here too, USA has the highest number of publications in international collaboration. The other countries of international collaboration ranked on the basis of

number of international collaboration are China, Japan, South Korea, Italy, Sweden etc. Though there are many countries, the less collaborative countries are not listed in the table to avoid a long list in all the tables presented in the study.

The Table 3 and Figure 1 presents the collaborative pattern of authors of US region. It is seen from the table that China, Spanish and South Korean authors. The table is also indicate that the US on the subject are mostly preferred for team research. The Table 4 and Figure 2 are also confirming results authors on the subject are mostly preferred for team presented in the Table 3 that the US authors and Chinese authors on the subjects are more willing to collaborate themselves than the author of other countries. The Table 5 and Figure 3 indicate that the

**Table 3:** International Collaborative patterns of authors of US

S. No.	Countries	Publications	Percent
1	China	1385	19.84
2	Spain	383	5.49
3	South Korea	323	4.63
4	England	322	4.61
5	Italy	306	4.38
6	Japan	272	3.90
7	Canada	255	3.65
8	Sweden	227	3.25
9	Switzerland	221	3.17
10	Brazil	192	2.75
11	North America	168	2.41
12	Taiwan	167	2.39
13	India	156	2.23
14	Australia	141	2.02
15	Mexico	137	1.96
16	Israel	136	1.95
17	Singapore	133	1.90
18	Russia	130	1.86
19	Turkey	109	1.56
20	Netherlands	105	1.50
21	Iran	104	1.49
22	Ukraine	103	1.48
23	Oman	100	1.43
24	Belgium	96	1.37
25	Portugal	92	1.32
26	Tunisia	74	1.06
27	Poland	70	1.00
28	Denmark	69	0.99
29	Ireland	69	0.99
30	Hong Kong	68	0.97
31	Czech Republic	64	0.92

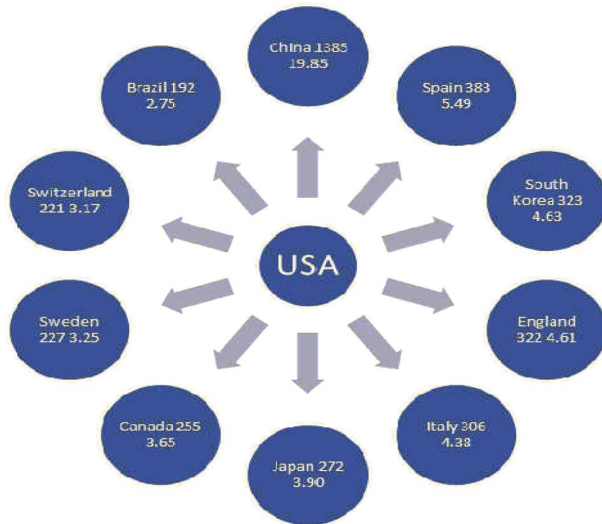


Fig. 1: International Collaborative pattern of authors US

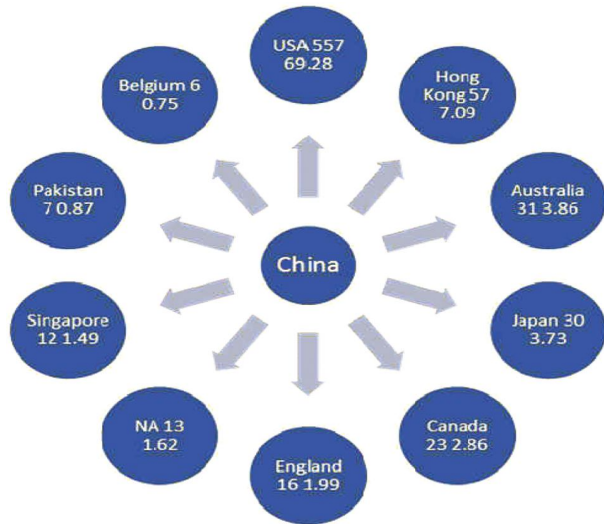


Fig. 2: International Collaborative pattern of Chinese authors

Table 4: International Collaborative pattern of Chinese authors

S. No.	Country	Publications	Percent
1	USA	557	69.28
2	Hong Kong	57	7.09
3	Australia	31	3.86
4	Japan	30	3.73
5	Canada	23	2.86
6	England	16	1.99
7	Na	13	1.62
8	Singapore	12	1.49
9	Pakistan	7	0.87
10	Belgium	6	0.75
11	Saudi Arabia	6	0.75
12	Sweden	6	0.75
13	Finland	5	0.62
14	India	4	0.50

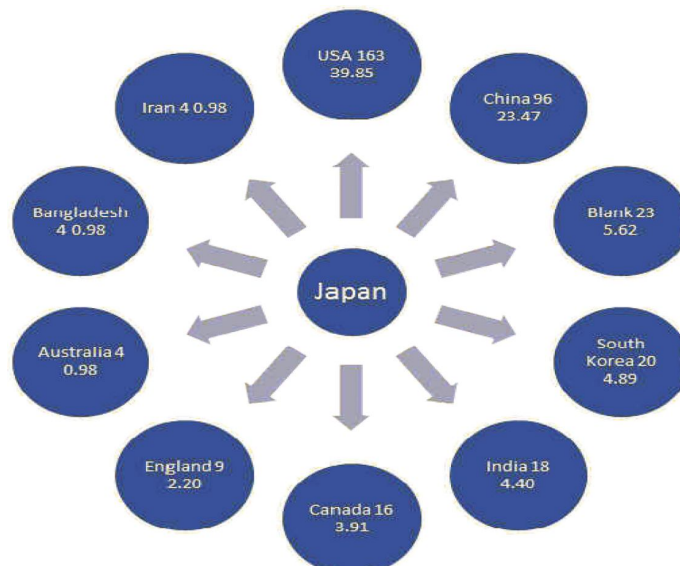


Fig. 3: International Collaboration of Japanese authors

**Table 5:** International Collaboration of Japanese authors

S.No.	Countries	Publications	Percent
1	USA	163	39.85
2	China	96	23.47
3	HonKong	23	5.62
4	South Korea	20	4.89
5	India	18	4.40
6	Canada	16	3.91
7	England	9	2.20
8	Australia	4	0.98
9	Bangladesh	4	0.98
10	Iran	4	0.98
11	Israel	4	0.98
12	Italy	4	0.98
13	Malaysia	4	0.98
14	Czech Republic	3	0.73
15	Egypt	3	0.73
16	Germany	3	0.73
17	Thailand	3	0.73

**Table 6:** International Collaboration of South Korean authors

S. No.	Countries	Publications	Percent
1	USA	229	57.25
2	India	29	7.25
3	Japan	28	7
4	China	25	6.25
5	Oman	13	3.25
6	England	12	3
7	Saudi Arabia	11	2.75
8	Na	11	2.75
9	Scotland	7	1.75
10	Canada	6	1.5
11	Russia	5	1.25
12	Australia	4	1

**Table 7:** International Collaboration of Italian authors

S. No.	Countries	Publications	Percent
1	USA	188	53.11
2	England	15	4.24
3	Na	12	3.39
4	Oman	10	2.82
5	Czech Republic	9	2.54
6	Finland	9	2.54
7	Ireland	9	2.54
8	Morocco	9	2.54
9	Slovakia	7	1.98
10	Belgium	6	1.69
11	Greece	6	1.69
12	Sweden	6	1.69
13	Switzerland	6	1.69
14	Canada	5	1.41
15	India	5	1.41
16	Bulgaria	4	1.13

**Table 8:** International Collaboration – Swedish authors

S. No.	Country	Publications	Percent
1	USA	60	17.86
2	Russia	33	9.82
3	England	18	5.36
4	China	17	5.06
5	Lithuania	17	5.06
6	India	15	4.46
7	Oman	15	4.46
8	Denmark	14	4.17

9	Austria	13	3.87
10	Italy	10	2.98
11	Belgium	9	2.68
12	Poland	9	2.68
13	North Ireland	8	2.38
14	Spain	8	2.38
15	(Blank)	8	2.38
16	Czech Republic	7	2.08
17	Ireland	7	2.08
18	Japan	7	2.08
19	Egypt	6	1.79
20	Netherlands	6	1.79
21	Norway	6	1.79
22	Pakistan	5	1.49
23	Brazil	4	1.19
24	Finland	4	1.19
25	Iran	4	1.19
26	Slovakia	4	1.19
27	Ethiopia	3	0.89

**Table 9:** International Collaboration–Spanish Authors

S. No.	Country	Publications	Percent
1	USA	149	45.99
2	Ireland	17	5.25
3	Mexico	13	4.01
4	Brazil	12	3.70
5	England	12	3.70
6	Portugal	12	3.70
7	(Blank)	12	3.70
8	Denmark	8	2.47
9	Italy	8	2.47
10	Japan	8	2.47
11	North Ireland	8	2.47
12	Oman	7	2.16
13	Cuba	5	1.54
14	Argentina	4	1.23
15	Iran	4	1.23

**Table 10:** International Collaboration –Authors from England

S. No.	Country	Publications	Percent
1	USA	116	37.91
2	China	34	11.11
3	Na	21	6.86
4	Wales	15	4.90
5	Australia	13	4.25
6	Scotland	13	4.25
7	Denmark	8	2.61
8	Japan	8	2.61
9	Canada	7	2.29
10	Czech Republic	7	2.29
11	Brazil	5	1.63
12	Netherlands	5	1.63
13	Sweden	5	1.63
14	Austria	4	1.31
15	Croatia	4	1.31
16	Ireland	4	1.31
17	Italy	4	1.31
18	Spain	4	1.31
19	Switzerland	4	1.31

**Table 11:** International Collaboration – Taiwan Authors

S.No.	Country	Publications	Percent
1	USA	134	69.43
2	India	13	6.74
3	Saudi Arabia	10	5.18

4	Japan	6	3.11
5	China	4	2.07
6	Hong Kong	4	2.07
7	Canada	2	1.04
8	Denmark	2	1.04
9	Egypt	2	1.04
10	England	2	1.04
11	Poland	2	1.04
12	Singapore	2	1.04
13	Australia	1	0.52
14	Indonesia	1	0.52
15	Mexico	1	0.52
16	Oman	1	0.52
17	Scotland	1	0.52
18	South Africa	1	0.52
19	South Korea	1	0.52
20	Spain	1	0.52
21	Sweden	1	0.52
22	Turkey	1	0.52
		193	100.00

**Table 12:** International Collaboration – Indian Authors

S.No.	Country	Publications	Percent
1	USA	59	39.86
2	South Korea	36	24.32
3	Japan	12	8.11
4	England	7	4.73
5	Bulgaria	4	2.70
6	china	3	2.03
7	Australia	2	1.35
8	Canada	2	1.35
9	Ethiopia	2	1.35
10	Germany	2	1.35
11	Peru	2	1.35
12	Saudi Arabia	2	1.35
13	Singapore	2	1.35

Japanese authors are also preferred for collaborative research with that of USA, Chinese and HongKong. And 4.40 percent of Japanese authors are also collaborated with Indian authors. The International collaboration of South Korean authors presented in the Table 6 indicates that these authors are collaborated with USA and interestingly to note that 7.25 percent of Korean authors are also collaborated with Indian authors. The Table 7 illustrates that more than 50 percent of Italian authors are collaborated with USA authors followed by this 4.24 percent of these authors are also collaborated with UK authors.

The Table 9 International Collaboration – Spanish Authors 8 presents the collaborative patterns of Swedish authors. These authors are also mostly collaborated with US authors and 4.46 percent of these authors are also collaborated with Indian authors, subsequently 1.49 percent of Pakistani authors are also collaborated with Swedish authors. The Table 9, 10 and 11, 12 illustrates that the authors of Spanish, UK, Taiwan are mostly collaborated with US authors. The Table 12 indicates that the Indian authors are mostly collaborated with USA, South Korea and Japan.

### Summary and Conclusion

The international collaboration pattern of leading countries shows interesting results.

- USA has the highest collaboration with China followed by Spain, South Korea, England etc.
- China has the highest collaboration with USA followed by Hong Kong, Australia, Japan, Canada and England etc.
- Japan has the highest collaboration with USA. The other highest collaborating countries are mainly Asian countries like China, South Korea and India.
- South Korea has the highest collaboration with USA. The other highest collaborating countries are mainly Asian countries like India, China and Japan.
- Italy has the highest collaboration with USA followed by England, Oman, Czech Republic etc.
- Sweden has the highest collaboration with USA

followed by Russia, England, China, Lithuania, India etc

- Spain has the highest collaboration with USA. The other leading collaborating countries are European countries like England, Ireland, Portugal etc
- England has the highest collaboration with USA followed by China, Wales, Australia, Scotland etc
- Taiwan has the highest collaboration with USA. The other leading collaborating countries are mostly Asian countries like India, Saudi Arabia, Japan, China etc
- India has the highest collaboration with USA. The other leading collaborating countries are mostly Asian countries like South Korea and Japan.
- On the whole, USA has the major collaboration with other countries of the world.

From the results of the study it can be noted that the Bioelectronics research is mostly a team research and as well as most of the authors of the different countries are preferred to collaborate with US authors, the reason may be that the US has excellent infrastructure facilities for the research of Bioelectronics.

## References

1. Dutt, Bharvi & Nikam, Khaiser. Scientometrics of collaboration pattern in solar cell research in India. *Annals of Library and Information Studies (ALIS)*. 2014; 61(1): 65-73.
1. Elango, B. & Rajendran, P. Authorship trends and collaboration pattern in the marine sciences literature : a scientometric study. *International Journal of Information Dissemination and Technology*. 2012; 2(3): 166-169.
2. Sangam, S. L.; Kiran Savanur & Manjunath M. Communication and collaborative research pattern of Sivaraj Ramaseshan: A scientometric portrait., *Scientometrics*. 2007; 71(2): 217-230.
3. Liang, Liming ; Guo, Yongzheng & Davis, Mari . Collaborative patterns and age structures in Chinese publications. *Scientometrics*. 2002; 54(3): 473-489.
4. Anuradha, K. T. & Shalini R. Bibliometric indicators of Indian research collaboration patterns: A correspondence analysis, *Scientometrics*. 2007; 71(2): 179-189.
5. Li, Chengchao; Zhao, Pengpeng ; Wu, Jian; Mao, Jiumei & Cui, Zhiming . An Item-Based Collaborative Filtering Framework Based on Preferences of Global Users, paper presented 4<sup>th</sup> International conference on computer engineering and network. 04 December 2014; 1113-1120.
6. Fawaz Abdullah Alhamdi & Babasaheb Ambedkar. Authorship and collaborative patterns in *Annals of Library and Information studies*, 2007-2013 : A scientometric study, *International Journal of Digital Library Services IJODLS*. 2015; 5(1): 117-129.
7. Kaliyaperumal, K. & Natarajan, K. Scientometric Analysis of Literature Output on Retina. *DESIDOC Journal of Library & Information Technology*. July 2009; 29(4): 33-36.
8. Sangam, S.L., The concept of scientometrics, *Scientometric studies,UGC/SAP/DRS-I*. National workshop papers and proceedings. 25<sup>th</sup>-27<sup>th</sup> Oct. 2010; Dharwad, pp.1-9.
9. Gayatri Mahapatra, *Bibliometric studies : In the internet era*, New Delhi : Indiana publishing house. 2009; pp. 1-59.
10. Gopal, W. *Bioelectronics and Nanotechnologies. Biosensors and Bioelectronics*. September 1998;13(6): 723-728.