

A Bibliometrics Analysis of Photosynthesis Research Productivity: Study Based on Web of Science Database

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Abstract - An analysis of 53839 publications published by scientist during the time span of 1989 to 2014 and indexed by Web of Science online Database indicates that the publications output in the Photosynthesis Research. The Chinese Academic Sciences, Russian Academic Sciences and Australian National University were the most producers of research output in Photosynthesis. It is observed that its relative growth rates contracted progressively from 0.302 at 1989 to 0.116 in the year of 2014. The whole study period sample mean relative growth rate is 0.10. Contrary to this, the Doubling Time for publication of all sources in Photosynthesis research output decreased from 2.29 years in 1989 to 5.97 years in 2014. During the study period, doubling time value is 25.11 years. This work is to provide a profile of research in Photosynthesis research publications in global level.

Keywords: Bibliometrics, Photosynthesis, H-index, Citation Score, Relative Growth Rate, Doubling time

I. INTRODUCTION

Use by green plants of the energy in sunlight to carry out chemical reactions, such as the conversion of carbon dioxide into oxygen. Photosynthesis also produces the sugars that feed the plant. The process by which green plants, algae, diatoms, and certain forms of bacteria make carbohydrates from carbon dioxide and water in the presence of chlorophyll, using energy captured from sunlight by chlorophyll, and releasing excess oxygen as a byproduct. In plants and algae, photosynthesis takes place in organelles called chloroplasts. Photosynthesis is usually viewed as a two-step process. First, in the light reactions, the energy-providing molecule ATP is synthesized using light energy absorbed by chlorophyll and accessory pigments such as carotenoids and phycobilins, and water is broken apart into oxygen and a hydrogen ion, with the electron of the hydrogen transferred to another energy molecule, NADPH. The ATP and NADPH molecules power the second part of photosynthesis by the transfer of electrons. In these light-independent or dark reactions, carbon is broken away from carbon dioxide and combined with hydrogen via the Calvin cycle to create carbohydrates. Some of the carbohydrates, the sugars, can then be transported around the organism for immediate use; others, the starches, can be stored for later use.

II. OBJECTIVES

The main objective of this study was to use bibliometrics analysis the key features of Photosynthesis research activities at Global level.

1. To identify and analysis of distribution of Year Wise Photosynthesis Research Productivity during period 1989-2014;
2. To identify Document Wise Distribution of Photosynthesis Research Output;
3. To identify Country Wise Distribution of Photosynthesis Research Output; and
4. To assess the Institution wise research concentration of Research Output.

III. METHODOLOGY

“Photosynthesis” is the search string for receiving data from the database 53839 records were downloaded. This analytical study encompassing records output available on Web of Science database. The present study aims at analyzing the research output of researchers in the field of Photosynthesis. The growth rate of outputs in terms of research productivity is analyzed from 1989 to 2014. Further, an attempt is made to measure the performance of researchers and their research concentration in the field of Photosynthesis and it is also analytical in nature in strengthening the empirical strength due to application of suitable statistical tools.

IV. ANALYSIS AND INTERPRETATION

The researcher has chosen the years for analysis 1989 to 2014 (totally twenty six years); 53,839 records were downloaded from the web of knowledge database for this analysis on the subject of photosynthesis research productivity at worldwide. There are variations in the number of publications of articles during this sample period taken for the study. The below table value analysis reveals the year wise growth trend.

TABLE I YEAR WISE DISTRIBUTION OF PHOTOSYNTHESIS RESEARCH PRODUCTIVITY DURING 1989 TO 2014

S.No	Year	Records	%	Rank	TLCS	TGCS
1	1989	360	0.7	17	8694	16778
2	1990	487	0.9	16	6866	14134
3	1991	1479	2.7	15	24416	65664
4	1992	1552	2.9	14	23975	65909
5	1993	1560	2.9	14	21328	66226
6	1994	1585	2.9	14	22088	64049
7	1995	1782	3.3	11	23083	68589
8	1996	1899	3.5	13	23299	77178
9	1997	1854	3.4	12	21550	75321
10	1998	1821	3.4	12	20605	73586
11	1999	1764	3.3	11	20322	69718
12	2000	1774	3.3	11	18040	72155
13	2001	1786	3.3	11	19871	77224
14	2002	1878	3.5	10	20059	74809
15	2003	1970	3.7	9	18064	70171
16	2004	2042	3.8	8	18807	79690
17	2005	2159	4.0	7	17214	72754
18	2006	2140	4.0	7	14210	63444
19	2007	2360	4.4	6	14925	65250
20	2008	2481	4.6	5	14305	64537
21	2009	2636	4.9	4	13069	60108
22	2010	2651	4.9	4	10269	49802
23	2011	2662	4.9	4	7329	33778
24	2012	3378	6.3	3	6753	33814
25	2013	3664	6.8	2	3564	21882
26	2014	4115	7.6	1	811	8083
	Total	53839	100		413516	1504653

Note: TLCS – Total Local Citation Scores; TGCS – Total Global Citation Scores

The above table shows that the year wise distribution of research analysis, the year 2014 has highest number of publications 4115 (7.6%) with 811 of TLCS and 8083 of TGCS values and has secured the first position among the 26 years output in the Photosynthesis research at complete level.

The year 2013 has 3664 (6.8%) records and it stood in second position with 3564 of TLCS and 21882 of TGCS 2012 has 3378 (6.3%) publications and stood in the third position along with 6753 of TLCS and 33814 of TGCS.

Next to that 2011, 2010 and 2009 have 4.9 per cent of records; 2008 has 4.6 per cent of records; 2007 has 4.4 per cent of records; 2006 and 2005 have 4.0 per cent of records; 2004 has 3.8 per cent of records; 2003 has 3.7 per cent of records; 2002 and 1996 have 3.5 per cent of records; 1997 and 1998 have 3.4 per cent of records; 1995, 1999, 2000 and 2001 have 3.3 per cent of records; 1992, 1993

and 1994 have 2.9 per cent of records; 1991 has 2.7 per cent of records; and the remaining years 1990 and 1989 produced below one per cent of articles in photosynthesis research.

According to TLCS (Total Local Citation Scores) the following results were found from the above analysis: totally 4,13,516 TLCS were measured; among those, 1991 has highest TLCS scores, 24,416 with first position for TLCS; 1992 has 23,975 with second position; and 1996 has 23,299 of TLCS values with third position.

Examined by TGCS (Total Global Citation Scores) the overall period has 15,04,653 citation scores. Among those twenty six years, 2004 has highest TGCS scores, 79,690 with first position; 2001 has 77,224 with second position; 1996 has 77,178 of TGCS values with third position.

It could be derived from the above analysis, that the most productive years are 2014, 2013 and 2012. The publication

rate has increased from the value of 0.7 percent to 7.6 percent. It shows that growth rate increased more than seven times during 1989 to 2014. It is particularly identified that there is no relation between the productivity of publication

between the citation scores. The years 1991, 1992 and 1996 have highest TLCS and 2004, 2001 and 1996 have TGCS scored measured.

TABLE II ANALYSIS OF DOCUMENT WISE DISTRIBUTION OF PHOTOSYNTHESIS RESEARCH OUTPUT

S. No.	Document Type	Records	Percent	TLCS	TGCS
1	Article	46396	86.2	322993	1168636
2	Review	3095	5.7	61483	228953
3	Article; Proceedings Paper	2571	4.8	21444	80507
4	Meeting Abstract	623	1.2	51	106
5	Editorial Material	392	0.7	2144	6629
6	Note	277	0.5	2213	6264
7	Review; Book Chapter	133	0.2	2367	9946
8	Letter	106	0.2	603	2793
9	News Item	75	0.1	124	294
10	Correction	61	0.1	22	60
11	Biographical-Item	36	0.1	29	82
12	Bibliography	23	0.0	1	1
13	Correction, Addition	17	0.0	2	12
14	Reprint	10	0.0	6	23
15	Item About an Individual	9	0.0	23	31
16	Article; Book Chapter	4	0.0	5	223
17	Book Review	4	0.0	0	0
18	Discussion	4	0.0	5	18
19	Database Review	1	0.0	1	37
20	Poetry	1	0.0	0	0
21	Software Review	1	0.0	0	38

The above table shows that the sample 53,839 records were downloaded from the web of science database in the form of twenty one (21) document types brought out in Photosynthesis research output: Journal Articles; Review; Article, Proceeding papers; Meeting Abstract; Editorial Material; Note; Review, Book Chapter; Letter; News item; Correction; Biographical item; Bibliography; Correction, Addition; Reprint; Item about an Individual; Article, Book Chapter; Book review; Discussion; Database Review; Poetry and Software review.

The researcher has found the results from the table 2 that the articles from journal source capture the first position of highest 46396 (86.2%) publications. These articles covered 322993 TLCS and 1168636 TGCS scaled. It occupies significant place in journals as a medium of scientific communication more than any other form of publication. Majority of the Photosynthesis scientists have published their research papers in journals. Hence, the first (the journal source of publication of Photosynthesis research output occupies the predominant place in comparison with other sources of publications). So the hypothesis which is noted in chapter 3 has been substantially proved.

Next to that the sources of Review with research publication output 3095 (5.7%) along with 61483 LCS and 228953 GCS values were observed in the study and it stood in the second position of produced Photosynthesis research output. Another source of articles in Proceedings papers format produced 2571 (4.8%) articles along with 21444 TLCS and 80507 TGCS was measured; it stood at the third position based on their production of Photosynthesis research. Remaining eighteen sources produced very less number of articles in Photosynthesis research during 1989 to 2014.

It is concluded from this analysis that Journal articles have tremendous level and the sources of Article, Proceeding papers, Review, Editorial Material and Meeting Abstract were having their publication level at medium level and the remaining sources were having very low level of publishing the Photosynthesis research articles. By observing citation scores analysis, the form article scored highest values followed by the source of review, conference proceedings and editorial materials respectively.

Totally 166 countries contributed from various continents. Among those USA contributed 15691 (29.14%) of articles

and being in first rank position of publication level in photosynthesis research. Followed by Germany produced 6012 (11.17%) of articles, China produced 5019 (9.32 %)

of articles in photosynthesis research during the sample period.

TABLE III MOST PRODUCTIVITY COUNTRIES OF PHOTOSYNTHESIS DURING 1989-2014 (TOP 15 COUNTRIES)

S.No.	Country	No. of output	%
1	USA	15691	29.14
2	GERMANY	6012	11.17
3	PEOPLES R CHINA	5019	9.32
4	JAPAN	4312	8.01
5	ENGLAND	3273	6.08
6	AUSTRALIA	3129	5.81
7	FRANCE	3078	5.72
8	CANADA	2917	5.42
9	SPAIN	2396	4.45
10	ITALY	1901	3.53
11	INDIA	1895	3.52
12	NETHERLANDS	1655	3.07
13	RUSSIA	1406	2.61
14	SWEDEN	1384	2.57
15	BRAZIL	1198	2.23

India stood in the eleventh position in photosynthesis research publications. The researcher has taken the Indian productivity of photosynthesis for further analysis.

Various institutions or universities produced 53839 photosynthesis research articles. Totally 13088 institutions were observed from the selected sample data during 1989 to 2014. Among them the researcher has taken the first 25 higher publication (more than 300 research output) institutions priority of their highest research output only for this analysis. The researcher has given the ranks between first and 24th by their highest productivity of research outputs on Photosynthesis.

The table 4 indicates the institution wise research productivity on Photosynthesis during 1989 to 2014. The “Chinese Academic Sciences” has produced 1852 (3.4 %) publications along with 5880 LCS; 22038 GCS values were scaled securing the first rank position. Next to that “Russian Academic Sciences” has contributed 838 (1.6 %) publications along with 3363 LCS; 10122 GCS values holding in second rank; “Australian National University” has contributed 618 (1.1 %) publications along with 13129 LCS (highest); 27913 GCS (highest) values holding third rank position.

“USDA ARS” has contributed 612 (1.1 %), “University Illinois” has contributed 580 (1.1 %) publications, “University Calif Berkeley” has contributed 569 publications; “INRA” produced 557 publications; “University of Tokyo” has produced 521 articles and

“CSIC” has produced 515 articles. The remaining institutions contributed below 500 articles.

It could be concluded from the above discussion that the institutions “Chinese Academic Sciences”, “Russian Academic Sciences” and “Australian National University” were dominant institutions for contributing highest number of articles and identified as the most productive institutions among 13088 institutions on Photosynthesis research publications. They do vary from one institution to another.

The selected 25 institutions were not having equal productivity. This analysis has proved the fifth (There is a considerable level institution variation in the research output performance of Photosynthesis research) hypothesis.

According to GCS for most productive journals, the histriograph map analysis indicates that the top thirty nodes display the years 1989 to 2009 (duration period is 1989 to 2014) for selected 30 articles for this GCS map.

Among the selected 30 nodes, only fourteen journals repeatedly occurred on this LCS map. The journal “Annual Review of Plant Physiology and Plant Molecular Biology” occurred 8 times; the journal “Nature” occurred 6 times; the journal “Science” occurred 4 times;” Biochimica ET Biophysica ACTA” has 2 times; and the remaining ten journals occurred each one time of the selected nodes. The below histriographic map reveals the highest cited and link journals among the selected nodes.

In 1989, “Annual Review of Plant Physiology and Plant Molecular Biology” journal published 17 articles without any kind of links between the selected nodes with 1074 LCS, 2913 GCS and 164 CR values. Followed by “Oecologia” journal which published 48 articles without any kind of links between the selected nodes with 945 LCS,

1447 GCS and 83 CR values measured. In 1991, “Annual Review of Plant Physiology and Plant Molecular Biology” journal published 875 articles with four cited links between the selected nodes with 1387 (Highest LCS), 2332 GCS and 168 CR values.

TABLE IV INSTITUTION WISE RESEARCH OUTPUT ANALYSIS (TOP 25 INSTITUTIONS)

S.No.	Institution	No. of output	Rank	%	TLCS	TGCS
1	Chinese Academic Sciences	1852	1	3.4	5880	22038
2	Russian Academic Sciences	838	2	1.6	3363	10122
3	Australian National University	618	3	1.1	13129	27913
4	USDA ARS	612	4	1.1	6880	18598
5	University Illinois	580	5	1.1	10134	26899
6	University Calif Berkeley	569	6	1.1	8536	37338
7	INRA	557	7	1.0	4571	19931
8	University Tokyo	521	8	1.0	4351	15534
9	CSIC	515	9	1.0	3348	15388
10	University Sheffield	471	10	0.9	8050	22488
11	CNRS	455	11	0.8	4496	18835
12	University Florida	445	12	0.8	3767	12615
13	CNR	423	13	0.8	4204	12283
14	University of Wisconsin	391	14	0.7	6807	21494
15	University Copenhagen	368	15	0.7	2609	10075
16	Kyoto University	366	16	0.7	3477	11980
17	Washington State University	362	17	0.7	4820	11654
18	University California Davis	358	18	0.7	3504	14417
19	University Helsinki	349	19	0.6	2315	9043
20	Moscow MV Lomonosov State University	335	20	0.6	851	3780
21	University Toronto	316	21	0.6	4332	12428
22	University British Columbia	312	22	0.6	2487	11967
23	CSIRO	311	23	0.6	7482	18395
24	Tohoku University	311	23	0.6	3606	12546
25	University Georgia	308	24	0.6	2402	8395

In 1992, “Annual Review of Plant Physiology and Plant Molecular Biology” journal published 2352th (highest links) article with five quoted and one cited links between the selected nodes with 777 LCS, 1459 GCS and 155 CR values. “Chemical Reviews” journal published 2970 articles with only one quoted with 694 LCS, 2451 GCS and 157 CR values. “Biochimica Et Biophysica Acta” journal published 3672 articles with only one quoted link with 210 LCS, 1065 GCS and 157 CR values.

In 1993, “Biochimica Et Biophysica Acta” journal published 4856 articles with five quoted and one cited links between the selected nodes with 574 LCS, 1365 GCS and

183 CR values. In 1994, “Physiologia Plantarum” journal published 6975 articles with two quoted and one cited links between the selected nodes with 247 LCS, 1038 GCS and 185 CR values. In 1996, “Annual Review of Plant Physiology and Plant Molecular Biology” journal published 8858 articles without having any kind of links with 259 LCS, 1065 GCS and 219 CR values. “Annual Review of Plant Physiology and Plant Molecular Biology” journal published 8859 articles with two quoted and two cited links with 489 LCS, 1047 GCS and 120 CR values. In 1997, “Annual Review of Plant Physiology and Plant Molecular Biology” journal published 10732 articles with one

quoted links with 33 LCS, 1015 GCS and 132 CR values. “Science” journal published 11590 articles without having any kind of links with 41 LCS, 1395 GCS and 61 CR values.

In 1998, “Annual Review of Plant Physiology and Plant Molecular Biology” journal published 12600 articles with one quoted and one cited links with 326 LCS, 2453 GCS and 232 CR values. “Science” journal published 13755 articles with one quoted link with 235 LCS, 1287 GCS and 52 CR values.

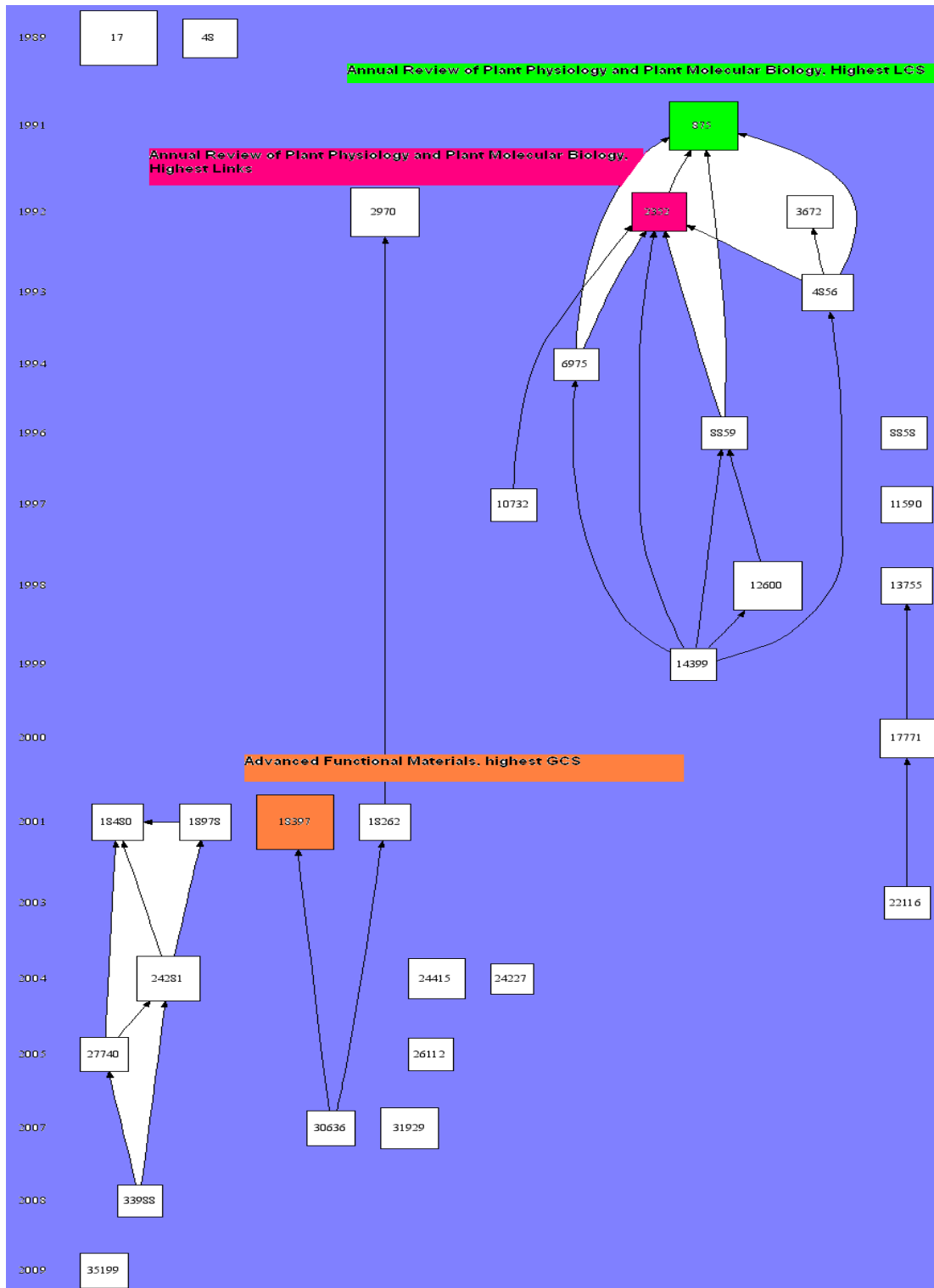


Fig.1 Histogram Maps of GCS for Journals (Nodes: 30, Links: 27, Min: 999, Max: 2965)

In 1999, “Annual Review of Plant Physiology and Plant Molecular Biology” journal published 14399 articles with five cited links with 450 LCS, 1083 GCS and 161 CR values. In 2000, “Nature” journal published 17771 articles with one quoted and one cited links with 184 LCS, 1566 GCS and 30 CR values. In 2001, “Accounts of Chemical Research” journal published 18262 articles with one quoted and one cited links with 324 LCS, 1386 GCS and 28 CR values. “Advanced Functional Materials” journal published 18397 articles with only one quoted link with 19 LCS, **2965 (highest GCS)** and 54 CR values. “Nature” journal published 18480 articles with three quoted links with 419 LCS, 1398 GCS and 30 CR values. “Nature” journal published 18978 articles with one quoted link with 393 LCS, 1346 GCS and 50 CR values measured.

In 2003, “Global Change Biology” journal published 22116 articles with one cited link with 124 LCS, 1085 GCS and 116 CR values. In 2004, “Plant Journal” journal published 24227 articles without having any kind of link with 151 LCS, 999 GCS and 35 CR values. “Science” journal published 24281 articles with two quoted and two cited links with 543 LCS, 1941 GCS and 50 CR values. “Nature” journal published 24415 articles without having any kind links with 347 LCS, 1711 GCS and 50 CR values. In 2005, “New Phytologist” journal published 26112 articles without have any kind of link with 359 LCS, 1090 GCS and 35 CR values. “Nature” journal published 27740 articles with two quoted and one cited link with 347 LCS, 1193 GCS and 30 CR values. In 2007, “Journal of Physical Chemistry C” journal published 30636 articles with two cited links with 60 LCS, 1172 GCS and 365 CR values. “Nature” journal published 31929 articles without have any kind of link with 6 LCS, 1590 GCS and 30 CR values.

In 2008, “Science” journal published 33988 articles with two cited links with 180 LCS, 1068 GCS and 22 CR

values. In 2009, “Nature Materials” journal published 35199 articles without have any kind of link with 56 LCS, 1196 GCS and 27 CR values.

V.CONCLUSION

The present study describes the bibliometrics analysis of the Photosynthesis research output. The sample data has drawn global research interest documented by articles from 166 countries. Most articles come from countries with traditional high research output in USA, Germany, China but also countries like India, Netherlands, Russia have embarked on important research activity in this area. In the field of photosynthesis research found an even louder growth in publication during the sample time span. With the number of publications the number of authors /publication have also been increased over time. This expansion also facilitated the cooperation between workgroups from different countries. The majority of publications are published in English and it is difficult for non English journals to be included in the database. This is a major bias. The central hub of the research cooperation is the USA.

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