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MAPPING THE RESEARCH PRODUCTIVITY ON 'SYSTEMS BIOLOGY': A SCIENTOMETRIC STUDY

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ABSTRACT

his paper presents a detailed Scientometric analysis of research productivity of Systems Biology (SB). A total of 11901 records on systems biology literature were found in Web of Science (WoS) database for the period of 10 years from 2006 to 2015. USA is the most prolific country contributing 41.5% of total research output in systems biology followed by United Kingdom (14.4%). The top two journals were PLOS one and Molecular Systems Biology. The most productive publishers are BioMed Central holding 9.13%, Wiley Blackwell having 7.72% and Nature Publishing Group publishing 6.73% of total systems biology research literature. The research output was published in nine languages and English stands first. Harvard University contributed 322 publications, the maximum from an institution.

KEYWORDS:Scientometric s, Systems Biology, productive journals, document types, prolific



authors, institutional productivity.

INTRODUCTION:

Systems Biology (SB) is an interdisciplinary subject and it aims at understanding biological systems at system level. SB is a growing area in biology, due to progress in several fields. The most critical factor has been rapid progress in molecular biology, furthered by technologies for making comprehensive measurements on DNA sequence, gene expression profiles, protein-protein interactions, etc. With the ever-increasing fiow of biological data, serious attempts to understand biological systems as systems are now almost feasible. Handling this high-throughput experimental data places major demands on computer science, including database processing, modeling, simulation, and analysis. (Kitano, 2002) defines that "systems biology aims at system level understanding that requires a set of principles and methodologies that links the behaviors of molecules to systems characteristics and functions"

LITERATURE REVIEW

Mottoa, Garcia and Quintella (2016) made a study on 'Patentoscientometric approach to venture capital investment prioritization' and researchers have come up with new dimensions of various indicators such technology criterion, market criterion, team criterion. Study used

globally accepted method 'data envelopment analysis' (DEA) for comparative analysis. Analysis concluded that indicators used 'not only help in understanding the issues addressed in this study related to nonfinancial criteria (technology, market, divestment, and team) but also contribute to the construction of a method for prioritizing VC investments.'

Padma & Ramasamy (2016) carried out a bibliometric study on research output of 'e-Library science research journal'. The study focused on geographical distribution of productivity, country wise & state wise distribution of contributors, most productive institutes, state wise Science production index. Authors have collected altogether 521 records for three years from 2013 to 2015 and tools used for analysis is MS excel program. Study reveals that Research productivity from India is higher than foreign countries because India has contributed 504

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(96.3%) articles and only 17 articles i.e. 3.27% have been contributed by rest of the world.

Singh, Bansal, Singhal & Uddin (2015) presented scientometric analysis on 'Big Data' literature from Web of Knowledge (WoK) and Scopus databases. Research literature have been retrieved for the period of five years from 2010-2014. Researcher has collected 1415 articles from WoK and 6810 articles from Scopus database. United States stands first by contributing 48.98% and 32.82% publications in terms of total research output. In journal publishing, 'Computer' magazine published by IEEE Computer Society tops the list with the total of 26 papers. Harvard University stands first by publishing 43 articles and in all parameters as well.

Pal (2015) carried out a scientometric analysis on cryptographic research and primary data of 167 records have been collected from MathSciNet database. The study confined to the literatures published in the Journal of Cryptology for ten years from 2001 to 2010. Author examined research by analyzing publications growth, authorship pattern, collaboration trend and predominant areas. Study entailed an increasing trend of multi authored publications (46% in 2004 and 90% in 2009). In view of collaboration network, Anglo-American institutions were more open than their competitor and University of California, USA appeared on the top among the productive institutions. USA and Israel dominated cryptographic research.

Xiang, Zhang and Zhu (2015) carried a scientometric analysis on worldwide earthworm research. Authors collected literature data from 'Science Citation Index Expanded' during from period from 2010 to 2015 and HistCite tool was used to analysis the yearly output, country, institution, journal, and citation impact and citation relationships. Researcher found that earthworm research has increased during the study period and USA has contributed highest research output while institute 'Chinese Academy of Sciences' contributed highest research output. Study further reveals that majority of articles and Total Location Citation Score (TLCS) came from developed nations.

Alvi and Vinitha (2014) analyzed the research publications in Hepatitis during the period 2004 to 2013. The data collection was done with the help of Pubmed Database. They analyzed the authorship, authorship pattern and citation of publication in hepatitis research. The study reveals that the year-wise research output shows an increasing trend and among the records, articles publication covers 70.29%. The authorship pattern shows that multi author publications occupy the first position and the degree of collaboration is 1.022 in hepatitis research. The maximum contribution was by USA (15.01%) followed by China (13.94%), Japan (10.89%), Germany (9.14%) and Italy (8.93%).

Padma and Ramasamy (2013) carried out a bibliometric study of the journal "Journal of Information Literacy" (2007-2012) - a free online journal. The study focused on the authorship pattern, types of publications, citation study, no. of pages, institution-wise output, country-wise output, the degree of collaborative research, degree of collaboration, yearwise and volume-wise contributions etc. The findings reveal that: Single authors contributed 37 papers in Type I publication. The degree of collaboration is 0.51 indicating the domination of multiple authors over the single authors. On an average, 26.31% of the articles used 10-20 references. 63.30% of the articles were contributed by UK followed by 19.42 from USA. Loughborough University has contributed a maximum of 5 articles. 28 articles have 11-15 pages. There is an interinstitutional research to the extent of 23.07%.

OBJECTIVES OF THE STYDY

The objectives of the study are, inter alia:

- To show the year-wise distribution of research output in Systems Biology
- To show the document type-wise distribution of research output
- To show the country-wise distribution of research output
- To reveal the most prolific authors in System Biology literature
- To disclose the most prolific journals in systems biology research
- To show the most productive publishers in Systems Biology and
- To know the most prolific institutions in Systems Biology Research

DATA COLLECTION AND METHODOLOGY

Bibliographical data on Systems Biology research have been collected from Web of Science (WoS) of Thompson Scientific Inc, USA for the period of 10 years from 2006 to 2015. In WoS, We found a total of 11901 records as a result of the search query [TS = ("Systems Biology") Timespan = 2006–2015, Indexes = SCI-EXPANDED, SSCI, A&HCI]. The data collection comprises of records of various types like article, book review, review, meeting abstract, proceedings paper, note, editorial material, letter etc. Each record in WoS data contains 60 fields containing meta-data about the records, such as paper title (TI), author address (C1), citation references (Z9) etc. We have used the information contained in different fields for a standard scientometric and a text-based analysis.

Retrieved data have been fed into HistCite (a product of Web of Science) for performing various quantitative

analyses to get necessary inferences.

DATA ANALYSIS AND INTERPRETATION 1. Geographical Distribution of Research Productivity

S.No	Country	Records	Percent	LCS	GCS
1	USA	4933	41.5	12091	127138
2	UK	1709	14.4	5417	43692
3	Germany	1580	13.3	3559	33113
4	Peoples R China	936	7.9	1291	13535
5	France	611	5.1	1376	15112
6	Netherlands	562	4.7	1752	13932
7	Italy	543	4.6	761	8257
8	Canada	504	4.2	1624	18180
9	Spain	428	3.6	511	7455
10	Switzerland	421	3.5	1256	14679
11	Japan	403	3.4	1356	13583
12	Unknown	339	2.9	895	5487
13	Sweden	309	2.6	882	6957
14	Australia	306	2.6	374	6103
15	Denmark	230	1.9	847	7157
16	India	214	1.8	302	3494
17	South Korea	209	1.8	804	6048
18	Belgium	204	1.7	456	6260
19	Austria	187	1.6	533	4137
20	Israel	180	1.5	470	7142
21	Taiwan	142	1.2	133	2018
22	Finland	130	1.1	289	3177
23	Brazil	126	1.1	89	1224
24	Singapore	123	1	161	3325
25	Greece	118	1	311	1947

Table 1. Country wise publications in systems biology (top 25 countries)



Fig. 1 Growth rate of total publications of top 25 countries

Table 1 and Figure 1 show the top-25 country wise research output on systems biology. USA tops the table with 4933 (41.5%) publications followed by United Kingdom with 1709 (14.4%) publications & Germany with 1580 (13.3%) publications. India gets 16th rank with 214 publications (1.8%).

2. Most Prolific Journals in Systems Biology Research

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S.No	Source Name	No of	percentage	cumulative	cumulative			
		Publication		total	percentage			
1	PLOS One	431	4.64	431	4.64			
2	Molecular Systems Biology	416	4.48	847	9.12			
3	BMC Systems Biology	399	4.30	1246	13.41			
4	BMC Bioinformatics	250	2.69	1496	16.11			
5	Bioinformatics	237	2.55	1733	18.66			
6	Proceedings Of The National	224	2.41	1957	21.07			
	Academy Of Sciences Of The							
	United States Of America							
7	Proteomics	160	1.72	2117	22.79			
8	Molecular Biosystems	150	1.61	2267	24.41			
9	PLOS Computational Biology	136	1.46	2403	25.87			
10	Journal Of Proteome Research	117	1.26	2520	27.13			
11	Current Opinion In	116	1.25	2636	28.38			
	Biotechnology							
12	Nucleic Acids Research	105	1.13	2741	29.51			
13	Wiley Interdisciplinary Reviews-	99	1.07	2840	30.57			
	Systems Biology And Medicine							
14	BMC Genomics	98	1.06	2938	31.63			
15	Briefings In Bioinformatics	85	0.92	3023	32.54			
16	Febs Journal	81	0.87	3104	33.42			
17	Journal Of Theoretical Biology	79	0.85	3183	34.27			
18	Iet Systems Biology	72	0.78	3255	35.04			
19	Biosystems	67	0.72	3322	35.76			
20	Analytical Chemistry	64	0.69	3386	36.45			

Table 2. List of Top 20 Productive Journals



Fig.2. Top 10 Journals in which systems biology research is published

The most productive top 20 journals in Systems Biology have been listed in Table 2. PLOS One journal is ranked first

with 431 research articles on systems biology constituting 4.64% of total publications followed by Molecular Systems Biology and BMC Systems Biology journals with 4.48%(416) & 4.30% (399) respectively. These 20 journals alone have contributed 36.45% of total research output on Systems Biology.

3. Year-wise Distribution of 'Systems Biology' research output

Table 3 Year wise distribution of total publications						
S.No	Year	Records	Percentage	LCS	GCS	
1	2006	629	5.3	4027	32307	
2	2007	703	5.9	3600	30646	
3	2008	921	7.7	4027	34600	
4	2009	1108	9.3	3917	35904	
5	2010	1372	11.5	3547	37914	
6	2011	1435	12.1	2861	32056	
7	2012	1558	13.1	2231	24356	
8	2013	1477	12.4	1231	15750	
9	2014	1355	11.4	525	7448	
10	2015	1326	11.2	144	2300	
Total		11884	100	26110	253281	



Fig. 3 Year wise publication distributions

Table 3 and Fig.3 make it clear that the highest number of 1558 articles were published in 2012 with 13.1% followed by 1478 publications in 2013 and 1431 publications in 2011. The least number of documents (629, 5.3%) were published in 2006. The line graph shows that the growth rate of research output on system biology has grown rapidly from 2006 to 2012 and declined in 2014 and 2015.

4. Top 20 most productive Publishers on Systems Biology

S.No	Name of the Publisher	No of articles	% of 11901 articles
1	Biomed Central Ltd	1087	9.13
2	Wiley-Blackwell	919	7.72
3	Nature Publishing Group	801	6.73
4	Oxford University Press	622	5.23
5	Public Library Science	617	5.18
6	Elsevier Science	568	4.77
7	Springer	511	4.29
8	American Chemical Society	298	2.50
9	Royal Society Chemistry	255	2.14
10	Elsevier Science Ltd	251	2.11
11	Pergamon-Elsevier Science Ltd	238	2.00
12	National Academy of Sciences	224	1.88
13	Current Biology Ltd	206	1.73
14	Bentham Science Publ. Ltd	205	1.72
15	Academic Press Inc Elsevier Science	189	1.59
16	Elsevier Science Inc	164	1.38
17	Wiley-V C H Verlag Gmbh	162	1.36
18	Lippincott Williams & Wilkins	151	1.27
19	Frontiers Research Foundation	145	1.22
20	Academic Press Ltd- Elsevier Science Ltd	128	1.08

Table 4 : Top 20 publishers who published articles on systems biology



Figure 4 : Radar view of top 20 publishers

Table 4 and Fig.4 disclose the top 20 publishers on systems biology. Biomed Central Ltd (BMC) (1087, 9.13%), Wiley Blackwell (919, 7.72%) and Nature Publishing Group (NPG)(801, 6.473%). These 20 publishers have published 7741 (65.03%) documents on systems biology during the period 2006-2015. There are seven publishers with more than 500 publications, 7 publishers with 200-299 publications and six publishers have 120-190 publications on systems biology from 2006-2015.

5. Ranking of Prolific Authors

S.No.	Author	No of Publications		
1	Nielsen J	94		
2	Palsson BO	65		
3	Kell DB	62		
4	Wang Y	58		
5	Westerhoff HV	54		
6	Wolkenhauer O	50		
7	Aebersold R	50		
8	Nicholson JK	43		
9	Lee SY	39		
10	Chen LN	38		
11	Timmer J	37		
12	Vodovotz Y	37		
13	Klipp E	36		
14	Le Novere N	35		
15	Noble D	35		
16	Li Y	34		
17	Mendes P	33		
18	Holmes E	33		
19	Saez-Rodriguez J	32		
20	Price ND	31		

Table 5 List of most prolific authors on SB research

Table 5 depicts the ranking of most prolific authors based on number of publications during the study period. Nielsen J stands first with 94 publications. Palsson BO and Kell DB published 65 & 62 publications respectively and both are in second and third positions in the list. Figure 5 portrays most prolific authors in the systems biology research.



Figure 5 : Most prolific authors in systems biology Research

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6. Language-wise Distribution of SB Research Output

S.No.	Language	Number of publications	Percentage		
1	English	11830	99.40%		
2	French	19	0.16%		
3	German	17	0.14%		
4	Chinese	17	0.14%		
5	Spanish	13	0.11%		
6	Russian	2	0.02%		
7	Portuguese	1	0.01%		
8	Japanese	1	0.01%		
9	Polish	1	0.01%		
	Total 11901 100%				

Table 6. Language-wise distribution

Table 6 shows the language wise distribution of publications. 99.4% (11830) of research output is published in English followed by French (19, 0.16%) and German and Chinese (17, 0.14%).

7. Document type-wise Distribution of SB Research Output

Table 7 shows the document type-wise distribution of publications in SB research. The most preferred document type preferred by the researchers in the field of SB is articles. 7259 publications are 'Articles' (61.1%) followed by 2717 publications which are 'Reviews' (22.9%). The documents types such as editorial material, meeting abstract, proceedings paper, book chapters also get the preference of SB researchers.

Table 7. Docu	ment Type-wise	e Distribution
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S.No	Document Type	Recs	Percent	LCS	GCS
1	Article	7259	61.1	13927	155778
2	Review	2717	22.9	9131	75972
3	Editorial Material	631	5.3	855	5528
4	Meeting Abstract	489	4.1	11	24
5	Article; Proceedings Paper	393	3.3	1176	7795
6	Review; Book Chapter	177	1.5	690	6289
7	Article; Book Chapter	86	0.7	113	594
8	Letter	50	0.4	134	486
9	Correction	22	0.2	11	15
10	News Item	20	0.2	7	27
11	Software Review	13	0.1	1	522
12	Editorial Material; Book Chapter	10	0.1	0	0
13	Book Review	6	0.1	5	14
14	Database Review	6	0.1	0	142
15	Biographical-Item	4	0	48	89
16	Reprint	1	0	1	6

8. Most prolific institutions in SB research

S.No	Institution	Recs	Percent	LCS	GCS
1	Harvard University	322	2.7	1283	14114
2	University Manchester	259	2.2	1695	8328
3	University Calif San Diego	235	2	1575	10404
4	Chinese Acad Sci	214	1.8	417	3991
5	University London Imperial Coll Sci Technol & Med	196	1.6	879	6264
6	MIT	166	1.4	567	5567
7	Unknown	149	1.3	91	367
8	University Cambridge	146	1.2	595	4109
9	University Calif Los Angeles	140	1.2	324	4768
10	Johns Hopkins Univ	139	1.2	680	5299
11	University Washington	139	1.2	318	2872
12	Inst Syst Biol	135	1.1	1184	8406
13	University Oxford	131	1.1	488	2951
14	University Toronto	128	1.1	636	7330
15	Stanford Univ	127	1.1	389	4609
16	University Edinburgh	122	1	341	3570
17	ETH	120	1	608	6480
18	University Calif Berkeley	115	1	287	4045
19	University Pittsburgh	111	0.9	369	1684
20	CNRS	110	0.9	180	2404
21	Tech University Denmark	105	0.9	567	3455
22	University Michigan	100	0.8	226	2333
23	University Amsterdam	98	0.8	446	2000
24	Vrije University Amsterdam	97	0.8	675	2408
25	University Tokyo	94	0.8	288	2313

Table 8. Top 25 Institutes contributed more number of publications

Table 8 displays top 25 institutes in Systems Biology Research output. Harvard University has contributed 322 (2.7%) publications followed by University of Manchester (259, 2.2%) and University Calif San Diego (235, 2%). These 25 institutions have published 3698 (31.1%) documents in SB research during 2006-2015.

CONCLUSION

The study reveals that research on systems biology has to be seriously taken up in India as western countries have started doing more research in this field. Author suggests that Indian institutes may collaborate with countries such USA, UK and Germany for further study and to develop ourselves to attain greater height in the field of Systems Biology. Because life science research cannot happen in future without having hardcore knowledge on systems biology related studies. Funds can be allotted to motivate the Indian Academic or research institutes who are currently working in the field of Systems biology research.

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