

Research Paper

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Research Activities In Artificial Cell, 1991 2010: A Scientometric Analysis

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ABSTRACT

This article discusses the scientific productivity in the field of artificial cell for during the periods of 1970-2010, based on from Web of Science, through scientometrics. This study investigates the growth pattern of artificial cell literature and collaboration pattern of authors, collaborative countries and highly cited papers. The present study may be of help for the library professionals in developing strategic plan for management of science and technology libraries.

Keywords : Scientometrics; artificial cell; Bio technology, Growth rate; Collaboration Measures.

Introduction

Artificial cells are being actively investigated for medical and biotechnological applications. The earliest routine clinical use of artificial cells is in the form of coated activated charcoal for hemoperfusion. Implantations of encapsulated cells are being studied for the treatment of diabetes, liver failure and the use of encapsulated genetically engineered cells for gene therapy. We recently found that daily orally administered artificial cell containing a genetically engineered microorganism can lower the elevated urea level in uremic rats to normal levels and increase the survival of the animal. Furthermore, this can remove potassium, phosphate, uric acid and other waste metabolite from uremic plasma. Blood substitutes based on modified hemoglobin are already in Phase III clinical trials in patients with as much as 20 units infused into each patient during trauma surgery. Artificial cells containing enzymes are being developed for clinical trial in hereditary enzyme deficiency diseases and other diseases. Artificial cell is also being investigated for drug delivery and for use in other uses in biotechnology, Chemical engineering and medicine. Most of the researchers, the honey pot protocells could become a whole new class of antiviral drugs. The first artificial cell was created by Thomas Chang at McGill University. An artificial cell wall/cell membrane is made of polymersomes. The hemoglobin is placed in the center. In the late sixties Thomas Chang discovered that artificial cells could carry enzymes which could correct certain metabolic disorders, and he also developed an artificial cell filled with charcoal which could treat drug poisoning.

Objectives Of The Study

The main objectives of the study are

- To investigate the nature of growth of articles, exponential, linear and logistic;
- To know the Relative Growth Rate (RGR) of articles;
- To observe Dt (Doubling Time) for the articles to become double of the existing amount;

- To study the authorship pattern;
- To investigate the collaborative research trend in terms of Collaborative Index (CI); Degree of Collaboration (DC) and Collaborative Co-efficient.

Database And Methodology

The data for the study were retrieved from the Web of Science, Science Citation Index Expanded (SCIE), published by Thomson Reuters, by using relevant keywords related to Artificial cell field. Records pertaining to artificial cell were collected from 1991-2010.

To investigate the nature of growth of articles, exponential, linear and logistic were tested. The exponential growth is defined as $F(t) = a e^{bt}$

Where,

a = the initial size of literature i.e. at time $t=0$ and b , the continuous growth rate is related to the percentage by which the size increases each year.

The logistic has a lower limit and an upper limit or a ceiling beyond which the size cannot grow and can be represented mathematically as $U_t = K / 1$

Where, U = expected size of literature; K and μ = constants and t = time.

Similarly, the linear growth is represented as $U_e = a + bt$

Relative Growth Rate (RGR) and Doubling Time (Dt) had been applied. RGR means the increase in the number of articles per unit of time. The mean RGR of articles over the specific period of interval is represented as $Rt(P) = 1/t \log_e p(t)$

Rt = Relative Growth Rate of articles over the specific period of time.

$\log_e p(0)$ = Logarithm of initial number of articles

$\log_e p(t)$ = Logarithm of final number of articles

Similarly, RGR of subject's articles has increased in number of articles per unit of time. The

mean RGR of subject articles $Rt(SA)$ over the period the specific period of time is determined

as $Rt(SA) = 1/t \log_e p(t) \log_e p(0)$

$Rt(SA)$ = Relative Growth Rate of articles over the specific period of time.

$\log_e p(0)$ = Logarithm of initial number of articles

$\log_e p(t)$ = Logarithm of final number of articles

Dt (Doubling Time) has been calculated by the formula: Doubling Time $Dt = 0.693/R$

Dt (Doubling Time) is directly related to RGR and is defined as the time required for the articles to become double of the existing amount. If the number of articles in subject doubles during a given period, then the difference between logarithms of number at the beginning and at the end of this period must be the logarithm of the number 2. We used Napier logarithm and the taken value of $\log_e 2$ is 0.693. Hence, as per this (0.693) and an average growth rate we calculated by what time interval does the Napier logarithm of numbers increase by 0.693. So the Doubling time is calculated as $Dt(SA) = \log_e 2 / Rt(SA) = 0.693 / Rt(SA)$ Here, $Dt(SA)$ = average doubling time of subject articles

Analysis and Interpretation

Source wise data distribution considered for the study period is revealed in the below table. Twelve types of documents types of sources are taken from the sample and taken this study for analyzes. It could be noted that out of twelve document types, article is constituted highest 81.81 %, and it's stood the first rank of other sources. Followed by review and proceeding papers are taking the same (7.99 % and 7.70 %) level of percentage among the other sources and stood in second and third ranks. Meeting abstract is having with 1.32 % and Note with 0.59 %. Remaining document types of sources are editorial material, letter, correction, news items, addition, discussion and reprint are having below 0.4 %.

Table 1: Analyses of sources wise output on artificial cell publications

	Document Type	Record	% of 12774
1	Article	10450	81.81
2	Review	1021	7.99
3	Proceedings Paper	984	7.70
4	Meeting Abstract	168	1.32
5	Note	75	0.59
6	Editorial Material	47	0.37
7	Letter	11	0.09
8	Correction	6	0.05
9	News Item	6	0.05
10	Correction, Addition	3	0.02
11	Discussion	2	0.02
12	Reprint	1	0.01
	Total	12724	

Growth Of Literature

The purpose of the present piece of study is to assess the research productivity of various countries. To analyze the same, research articles published in various sources have been taken as a yardstick to measure the output and the rate of growth regarding the artificial cell by calculating relative growth rate and doubling time for publications. The following table presents the data for identity for the relative growth rate and doubling time for the taken sample.

The table clearly indicates, the value of an average RGR of article ($Rt(P)$) gradually increased from 0.70 to 2.51. Correspondingly the values of Doubling time of the articles ($Dt(P)$) gradually decreased from 1970 (0.99 years) to 2010 (0.28 years).

Table -2: Relative Growth Rate ($Rt(P)$) and Doubling Time (dt) of articles in Artificial Cell from 1970-2010.

Year	No. of articles	Cum. No. of articles	$\log_e 1^p$	$\log_e 2^p$	$Rt(P)$	Mean $Rt(P)$	$Dt(P)$	Mean $Dt(P)$
1970	1	1	-	0	-	0.64	-	0.71
1971	1	2	0	0.69	-		-	
1972	2	4	0.69	1.39	0.7		0.99	
1973	4	8	1.39	2.08	0.69		1.00	
1974	6	14	1.79	2.64	0.85		0.82	
1975	9	23	2.20	3.14	0.94	1.46	0.74	0.49
1976	7	30	1.95	3.40	1.45		0.48	
1977	14	44	2.64	3.78	1.14		0.61	
1978	19	63	2.94	4.14	1.2		0.58	
1979	14	77	2.64	4.34	1.7		0.41	
1980	15	92	2.71	4.52	1.81	2.33	0.38	0.29
1981	12	104	2.48	4.64	2.16		0.32	
1982	14	118	2.64	4.77	2.13		0.32	
1983	10	128	2.30	4.85	2.55		0.27	
1984	15	143	2.71	4.96	2.25		0.31	
1985	12	155	2.48	5.04	2.56	2.64	0.27	0.26
1986	7	162	1.95	5.09	3.14		0.22	
1987	13	175	2.56	5.16	2.60		0.26	
1988	11	186	2.40	5.23	2.83		0.24	
1989	14	200	2.64	5.30	2.66		0.26	
1990	32	232	3.47	5.45	1.98	1.13	0.35	0.65
1991	271	503	5.60	6.22	0.62		1.11	
1992	301	804	5.71	6.69	0.98		0.71	
1993	308	1112	5.73	7.01	1.28		0.49	
1994	427	1539	6.06	7.34	1.28		0.49	
1995	438	1977	6.08	7.59	1.51	1.89	0.45	0.37
1996	482	2459	6.18	7.81	1.63		0.43	
1997	512	2971	6.24	8.00	1.76		0.40	
1998	497	3468	6.21	8.15	1.94		0.36	
1999	579	4047	6.36	8.31	1.95		0.36	
2000	540	4587	6.29	8.43	2.14	2.24	0.32	0.31
2001	594	5181	6.39	8.55	2.16		0.32	
2002	602	5783	6.40	8.66	2.26		0.31	
2003	669	6452	6.51	8.77	2.26		0.31	
2004	761	7213	6.63	8.88	2.25		0.31	
2005	823	8036	6.71	8.99	2.28	2.43	0.30	0.28
2006	862	8898	6.76	9.09	2.33		0.30	
2007	884	9782	6.78	9.19	2.41		0.29	
2008	949	10731	6.86	9.28	2.42		0.29	
2009	960	11691	6.87	9.37	2.5		0.28	
2010	1033	12724	6.94	9.45	2.51		0.28	
Total	12724		171.89	246.39	73.81	1.85	16.94	0.42

The mean relative growth $Rt(P)$ for the first five years (from 1970 to 1975) indicates a growth rate of 0.64, whereas for the last five years (from 2006 to 2010) it was increased to 2.43. Further, Mean Doubling Time $Dt(P)$ for the first six years was 0.71 (years), and it decreased to 0.28 years in the last five years which shows mean relative growth rate of artificial cell literature shown decreasing trend. It may be due scattering of literature output in several communication channels which may not completely covered by the Web of Science. The scientists in the field of artificial cell contribute research 12724 literature to many national and international science and technology journals which may not included in the international database like web of science.

Authorship Pattern

By analyzing the authorship pattern, at international level 44205 authors were participated and 363 authors were participated at Indian level publishing in the area of artificial cell. An attempt has been made to analyze the research performance of individual scientists in artificial cell in India and global level. The contributions of individual scientists are varies. At global level the highest number of papers is 44 Papers with 0.34 % of by Chang TMS and followed by Tsuchida, E output is 42 Publications with 0.33 % and Kobayashi K has brought out in this filed 34 articles with 0.27 % and stood up first, second and third placed occupied of highest first 20 authors with respect to the number of articles dealing with artificial cell and published in the Web of Science source journals by Universal authors. An national level highest number of publications is Just 4 with 30 global citation (Mukherjee, A) and three authors (Basu T; Kumar S and Sharma CP) are published only three articles along with 12, 133 and 19 total global citations.

Table 3: Analyses of authorship pattern with national and universal level top twenty author's productivity of artificial cell

Indian Authors					Universal Authors		
s.no	Author	Records	TLCS	TGCS	Author	Records	%
1	Mukherjee A	4	0	30	CHANG, TMS	44	0.34
2	Basu T	3	3	12	TSUCHIDA, E	42	0.33
3	Kumar S	3	0	133	KOBAYASHI, K	34	0.27
4	Sharma CP	3	1	19	SAKAI, H	32	0.25
5	Aich P	2	1	5	ITO, Y	28	0.22
6	Bandyopadhyay K	2	1	23	LEE, J	28	0.22
7	Bhasin M	2	0	63	KIM, J	27	0.21
8	Biswas A	2	0	4	AKAIKE, T	26	0.20
9	Boyd MFR	2	1	3	BENZ, R	26	0.20
10	Das PK	2	1	23	FISCHER, U	26	0.20
11	Jana B	2	1	5	KOBAYASHI, T	24	0.19
12	Jha T	2	1	32	MATSUDA, T	23	0.18
13	Kaladhar K	2	1	16	IJIMA, H	22	0.17
14	Kamboj SS	2	1	29	NAKAZAWA, K	22	0.17
15	Kaur M	2	1	29	OSTERRIEDER, N	22	0.17
16	Kim J	2	0	18	TANAKA, M	22	0.17
17	Kim L	2	0	18	HUXLEY, C	20	0.16
18	Kotecha J	2	1	16	TIRRELL, DA	20	0.16
19	Krishnan LK	2	1	30	FREYSE, EJ	19	0.15
20	Lee J	2	0	18	FUSSENEGGER, M	19	0.15
363 Authors					44205 Authors		

Country Wise Distribution Of Publications

From various countries (25 countries from international and 18 countries from India) authors are collaborated with scientists from a number of countries, the number of papers published from different countries during 1970-2010 is shown in Table 5. The USA is the undoubted leader, followed by Japan, Germany, Canada, China, Italy, Netherlands, etc., including India. At universal countries are USA with 84.89 %, Japan with 14.44 %, Germany with 12.02 % are dominating the first, second and third places of their publication contributes among the 25 countries at international level. USA, France, Japan, Germany, Slovenia, South Korea and Sweden are highly contribution of artificial cell publications. And Australia, Belgium, Canada, Czech Republic, Finland, Kuwait, China and Singapore, Spain and Thailand countries are having very low publication of this area of artificial cell.

Collaborative Index

Collaborative Index can be obtained by total number of authors divided by total number of published articles. Collaborative index = total number of authors / total number of articles. Where, CI = It is the number of authors per paper. Result from the table 3 is showed that Authorship pattern and collaborative measures. The collaborative Index for universal level is 3.47; and the collaborative Index for national level is 3.15, which shows that collaborative research pattern than solo research.

Table 4: Collaboration Research Countries production of artificial cell publications

India Collaboration					Universal Level		
#	Country	Records	TLCS	TGCS	Country	Record	%
1	India	114	12	1138	USA	4457	34.89
2	USA	15	1	121	Japan	1845	14.44
3	France	5	1	27	Germany	1535	12.02
4	Japan	3	0	17	England	902	7.06
5	Germany	2	0	135	France	752	5.89
6	Slovenia	2	0	4	Canada	556	4.35
7	S. Korea	2	0	18	Peoples R China	544	4.26
8	Sweden	2	0	87	Italy	510	3.99
9	Australia	1	0	1	Netherlands	344	2.69
10	Belgium	1	0	2	Switzerland	340	2.66
11	Canada	1	0	2	South korea	327	2.56
12	Czech Republic	1	0	4	Australia	309	2.42
13	Finland	1	0	1	Spain	270	2.11
14	Kuwait	1	0	2	Sweden	270	2.11
15	Peoples R China	1	0	1	Scotland	192	1.50
16	Singapore	1	0	5	Austria	170	1.33
17	Spain	1	0	0	Belgium	158	1.24
18	Thailand	1	0	0	Taiwan	151	1.18
19					Russia	150	1.17
20					Brazil	131	1.03
21					Israel	124	0.97
22					Denmark	118	0.92
23					Poland	116	0.91
24					India	114	0.89
25					Finland	87	0.68

Highly Cited Articles

Here we analyses (table 5 and table 6) about the highly cited papers at national and international level. At international level taken just five articles, the first title on "Rag-1 Deficient Mice Have No Mature Lymphocytes-B And Lymphocytes-T" published by Mombaerts, P et.al., in the journal of Cell, vol:68 issue5, pp 869-877, 1992 has 1437 citations. This article is the highest citation among the 12724 articles. Second article, "BCL-2 FAMILY: Regulators of cell death", by Chao D T and Korsmeyer S J published in Annual Review of Immunology Vol: 16 pp: 395-419, 1998 has 973 citations and its dominated at the second place. Remaining three articles are having 942 citations, 841 and 795 citations. These three articles are published by the journals such names are Nature (2000), Nature Medicine (2001) and Science (1998). Here we could see the familiar author's publication is not in high cited. Table 5: Highly Cited papers from Universal

Title	Author	Source	Citations
Rag-1-Deficient Mice Have No Mature Lymphocytes-B And Lymphocytes-T	Mombaerts P, Iacomini J, Johnson RS, et al.	CELL Vol: 68 Issue: 5 Pages: 869-877 Published: MAR 6 1992	1,437
BCL-2 FAMILY: Regulators of cell death	Chao DT, Korsmeyer SJ	Annual Review Of Immunology Volume: 16 Pages: 395-419 Published: 1998	973
A synthetic oscillatory network of transcriptional regulators	Elowitz MB, Leibler S	NATURE Volume: 403 Issue: 6767 Pages: 335-338 Published: JAN 20 2000	942
Classification and diagnostic prediction of cancers using gene expression profiling and artificial neural networks	Khan J, Wei JS, Ringner M, et al.	NATURE MEDICINE Volume: 7 Issue: 6 Pages: 673-679 Published: JUN 2001	841
Bax and adenine nucleotide translocator cooperate in the mitochondrial control of apoptosis	Marzo I, Brenner C, Zamzami N, et al.	SCIENCE Volume: 281 Issue: 5385 Pages: 2027-2031 Published: SEP 25 1998	795

Table 6: Highly Cited Papers from India

Title	Author	Source, Year	Citations
Free heme toxicity and its detoxification systems in human	Kumar S, Bandyopadhyay U	TOXICOLOGY LETTERS Volume: 157 Pages: 175-188, 2005	87
Cyanobacterium-plant symbioses	Rai AN, Soderback E, Bergman B	NEW PHYTOLOGIST Volume: 147 Issue: 3 Pages: 449-481, 2000	87
Rheology of active-particle suspensions	Hatwalne Y, Ramaswamy S, Rao M, et al.	PHYSICAL REVIEW LETTERS Volume: 92 Issue: 11, 2004	82
Evaluation of an in situ forming hydrogel wound dressing based on oxidized alginate and gelatin	Balakrishnan B, Mohanty M, Umashankar PR, et al.	BIOMATERIALS Volume: 26 Issue: 32 Pages: 6335-6342, 2005	72
Effects of UV irradiation on certain physiological and biochemical processes in cyanobacteria	Sinha RP, Singh N, Kumar A, et al.	Journal of Photochemistry and Photobiology B-Biology Vol: 32 Issue: 1-2 Pages: 107-113, 1996	53

At Indian level, the author's kumar S and Bandyopadhyay U are leading authors of Indian scientist in the field of artificial cell publications. Their articles has 87 (Toxicology letters, 2005) journal is highly citations. Followed by the Rai AN et.al., article also has 87 (New Phytologist, 2000) journals has high citations. The third one article published by the journal name of physical review letters, 2004 it has 82 high citations. The fourth one article was published by the journal of Biomaterials, 2005 it has cited 72 times. At fifth article published from the journals of Photochemistry and Photo Biology B biology, 1996 has 53 times cited by the users.

Findings And Conclusion

The study reveals that the value of an average RGR of article ($R_t(P)$) gradually increased and the values of Doubling time of the articles $Dt(P)$ gradually decreased. Mean relative growth rate of Artificial cell literature showed decreasing trend. Collaborative research is predominant in artificial cell field. Scientometric studies help in the analysis of Research and Development trends; in identifying areas

that are most active and those which are gaining importance; identifying the influences and cross fertilizations. The scientific community has recognized artificial cell as thrust areas for research and human resource development. The study gives a synoptic view of global scientific productivity in the field artificial cell. It also brings out the influence of technology usage of artificial cell in all spares of human life.

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