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Authorship Pattern and Research Collaboration in the Field of Synthetic Biology

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Abstract: The study provides a complete view of authorship and collaborative patterns of global synthetic biology research. Data for the study was obtained from the Web of Science Core Collection database of Clarivate Analytics from 2005 to 2019. This study finds that the average number of authors per paper in the present data set is 4.56. The average productivity per author is 0.22, which shows that the number of authors and publications is increasing. The authorship pattern showed a remarkable increase in the number of multi-authored publications. The current data show a positive correlation between the number of publications and the number of authors. Further, the study finds higher rates of mean values of collaboration indicators (CI = 4.5576, DC = 0.8863, CC = 0.6483, and MCC = 0.6495) also proved the better rates of collaborations among authors in this field. The study concludes that synthetic biology researchers prefer team research over solo research.

Keywords: Authorship pattern, Research collaboration, Synthetic Biology, Collaborative index, degree of collaboration, Collaborative co-efficient, Modified collaborative co-efficient, Co-authorship Index.

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1. Introduction

The authorship pattern and productivity study is an essential aspect of scientometric studies. To determine the author's productivity and authorship pattern, the primary factor is the analysis of the nature of collaboration in research activity. Collaborative research activity is a well-recognized feature of modern science, and there has been a consistent trend toward increased cooperation in all branches of Science in recent times (Zafrunnisha & Pullareddy, 2009). The complexity of research in any discipline requires scientific collaboration to ensure the progress of knowledge. This collaboration often involves active participation of individuals, teams, and institutions from various disciplines, contribute their knowledge, skills, and abilities from different points of view and complement each other (Paula & Sancho, 2021). The current study presents insights into authorship and collaboration patterns of the research in synthetic biology from 2005 to 2019. Synthetic Biology is an emerging area of research in the field of Biological Sciences. It is a broad field that impacts numerous sectors of the economy, including food and agriculture, energy and climate, manufacturing and chemicals, and health and medicine. Synthetic biology has wide applications in developing and producing alternative routes for valuable compounds. In the recent past, synthetic biology has made rapid development, making substantial contributions to essential life science research, human health, environmental safety, and monetary growth (Wang and Zhang, 2019). Most of the quantitative studies reported in the literature have focused on core scientific domains, but the attention on Synthetic biology has received less attention.

2. Literature Review

Several scholars have studied issues such as the distribution of papers by the number of authors, the average number of authors on a publication, or their collaboration rate in various fields. Similarly, the strength of collaborations among authors in different subject areas was assessed by many authors using multiple indicators such as collaborative index, degree of collaboration,

collaborative co-efficient, modified collaborative co-efficient and co-authorship index, etc. The existing literature analysis reveals that so far, only a few partial scientometric studies have been carried out on Synthetic Biology literature (Oldham, Hall and Burton 2012; Hu and Rousseau 2015; Raimbault etal. 2016; Shapira et al. 2017). But so far, none of these studies analyses authorship and collaboration patterns in literature published in synthetic biology. Hence, the present studyattempts to fill up this gap in research.

3. Objectives of the Study

1. To analyze the nature of author productivity and authorship patterns in Synthetic Biology literature.
2. To examine the proportion of single versus multi-authored publications in Synthetic Biology
3. To determine the intense collaboration in Synthetic Biology domine using various collaboration measures, i.e., Degree of Collaboration, Collaborative Index, Collaborative Co-efficient, Modified Collaborative Co-efficient, and Co-authorship Index.
4. To identify the most prolific authors in Synthetic Biology
5. To visualize the co-authorship network of the most productive authors

4. Methodology

Data for this study were collected from the Web of Science (WoS) Core Collection database of Clarivate Analytics, Boston, USA, which is a leading and widely accepted database which is one of the most relied data source for doing scientometric studies. The following search string developed and suggested by Shappira et al. (2017) was used to obtain the necessary data for the present study.

(((TS = ("synthetic biolog*" OR "synthetic dna" OR "synthetic genom*" OR "synthetic *nucleotide" OR "synthetic promoter" OR

"synthetic gene* cluster") NOT TS = ("photosynthe*")) OR (TS = ("synthetic mammalian gene*" AND "mammalian cell") NOT TS = "photosynthe*") OR (TS = "synthetic gene*" NOT TS = ("synthetic gener*" OR "photosynthe*")) OR (TS = ("artificial gene* network" OR ("artificial gene* circuit*" AND "biological system")) NOT TS = "gener*") OR (TS = ("artificial cell") NOT TS = ("cell* telephone" OR "cell* phone" OR "cell* culture" OR "logic cell*" or "fuel cell*" or "battery cell*" or "load-cell*" or "geo-synthetic cell*" or "memory cell*" or "cellular network" or "ram cell*" or "rom cell*" or "maximum cell*" OR "electrochemical cell*"OR "solar cell*")) OR (TS = ("synthetic cell") NOT TS = ("cell* telephone" OR "cell* phone" OR "cell* culture" OR "logic cell*" or "fuel cell*" or "battery cell*" or "load-cell*" or "geo-synthetic cell*" or "memory cell*" or "cellular network" or "ram cell*" or "rom cell*" or "maximum cell*" OR "electrochemical cell*" OR "solar cell*" OR "photosynthe*")) OR (TS = ("artificial nucleic acid*" OR "artificial *nucleotide")) OR (TS= ("bio brick" or "biobrick" or "bio-brick"))))

Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Time span=2005-2019.

For data extraction, the researcher used the advanced search window of the WoS core collection database. The required data set was searched, identified, and downloaded from the subscribed version of the WoS database from Central Library, Pondicherry University, Pondicherry, India. By applying the above search strategy, 12,073 records were identified and saved in the WoS database. The data search and extraction were carried out on 15th August 2020. The same data set was downloaded and merged. Then this data set was further refined to exclude retracted and early access publications without complete information like volume number, issue number, page number, and year of publication and verified for identifying duplicate records. The researcher

identified 61 documents. The researcher again reopened the saved list in WoS and removed all these 61 records. After eliminating these records, the final data set constituted 12,012 records. This data set was selected as a data sample for the present research. The researcher included all the document types and languages in the current study. The downloaded data were further processed using Bibexcel (version 2017) and statistically analyzed using Microsoft Excel (office 2010) and SPSS (version 19). The VOSviewer (version 1.6.16) was used for network visualization. Table 1 provides the descriptive data for the publications in the sample.

Table 1 Overview of sample data

Sl.no	Description	Results
1	Period	2005:2019
2	Time-span	15 years
3	Number of publications	12,012
4	Number of authors	33,151
5	Author appearances	56,820
5	Average authors per paper	4.56
6	Productivity per author	0.22

The data set consists of 12,012 publications altogether contributed by 33,151 unique authors. There were 56,820 author appearances found. The average number of authors per paper in the present data set is 4.56, and the average productivity per author is 0.22.

5. Results and Discussion

5.1 Author Productivity

Table 2 presents the Productivity Per Author (PPA) and average Author Per Paper (AAPP) in Synthetic Biology literature. To calculate both AAPP and PPA, the authors used the formula suggested by Yoshikane et al. (2009) was used, and the same was given below.

Average Author Per Paper = number of authors/number of papers.
Productivity Per author = number of papers/number of authors.

Table 2: Author's productivity in Synthetic Biology

Year	Total number of publications	Total number of authors	Average Author per Paper	Productivity per Author
2005	202	917	4.54	0.22
2006	243	1,077	4.43	0.23
2007	257	1,111	4.32	0.23
2008	324	1,437	4.44	0.23
2009	407	1,631	4.01	0.25
2010	511	2,124	4.16	0.24
2011	585	2,486	4.25	0.24
2012	793	3,284	4.14	0.24
2013	838	3,785	4.52	0.22
2014	976	4,442	4.55	0.22
2015	1140	5,338	4.68	0.21
2016	1365	6,561	4.81	0.21
2017	1270	6,515	5.13	0.19
2018	1566	8,080	5.16	0.19
2019	1535	8,032	5.23	0.19
Total/ Average	**12,012**	**56,820**	**4.56**	**0.22**

It can be seen in Table 2 that around 56,820 authors were involved in the publication of 12,012 documents on Synthetic Biology from 2005 to 2019. The average number of authors per paper in the present data set is 4.56, and the average productivity per author is 0.22. AAPP ranging from 4.54 to 5.23 was observed during this period. The highest AAPP was observed in 2019, i.e., 5.23, and the lowest was in 2009 (4.01). Concerning AAPP, there were increasing trends from 2012 to 2019. In the case of PPA, there was a fluctuating trend. PPA ranged from 0.22 to 0.19 during this period. The highest PPA of 0.25 was observed in 2009, while the lowest was 0.19 in the last three years (2017 to 2019) under evaluation. It is inferred from this result that the number of authors increases along with the number of publications.

5.2 Correlation between the Number of Publications and the Number of Authors

Pearson correlation analysis was conducted to examine the correlations between the number of publications and the number of authors. The results show a significant and positive relationship ($r = 0.995$, $N=15$, $p = 0.000$). As the p-Value is < 0.05, it is highly significant. The correlation was strong in strength (Table 3). It means that a higher number of co-authors contributed to a higher number of papers.

Table 3: Correlation between the number of publications and the number of authors

		Number of publications	Number of authors
Number of publications	Pearson Correlation	1	.995**
	Sig. (2-tailed)		.000
	N	15	15
Number of authors	Pearson Correlation	.995**	1
	Sig. (2-tailed)	.000	
	N	15	15

Table 3: Correlation between the number of publications and the number of authors

		Number of publications	Number of authors
Number of publications	Pearson Correlation	1	.995**
	Sig. (2-tailed)		.000
	N	15	15
Number of authors	Pearson Correlation	.995**	1
	Sig. (2-tailed)	.000	
	N	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

5.3 Authorship Pattern

Table 4 reveals the authorship pattern of publications on Synthetic Biology from 2005 to 2019. The researchers included the occurrences of the authors in each record in the analysis. The pattern of authorship found in the research on Synthetic Biology during the selected period (2005-2019) varies from 1 author to 93 authors in single terms. It is clear from Table 4 (Annexure-1) that publications with three authors stood first with a score of 16.63 percent of total output, closely followed by publications with two authors with 16.38 percent, then four author publications with 14.38 percent, followed by five author publications with 11.36 percent and so on. Out of these 12,012 publications studied, the share of single-authored publications is only 10.35 percent, significantly less than multiple-authorship. As shown in Table 4 (Annexure-1), three author publications occupy the first position (16.63%) of total publications during the period under evaluation. Regarding the year dispersion, three author publications were around 14.36 percent of total output in a particular year. The percentage share of three author publications shows a downward growth during the period under investigation. It has a mean value of 77.23 and an SD of 78.56. Share reached the top in the year 2009 with 20.39 percent. In total, it shows a 101.72 percent variation during the whole period. Two author publications occupy the next spot (16.38%) share of total output during the period under evaluation. Two author publications were 16.83 in the initial year 2005, reaching up to 20.37 in 2008. Finally, two author publications reached 15.44 percent in 2019, indicating 100.11 percent of the variation in output during the period under evaluation. Four author publications occupy the third position (14.38%) share of total output. It was 13.86 percent in 2005, and finally, it went up to 13.94 percent in the year 2019. The four authors contributions show a 108.71 percent fluctuation throughout the period. 2019, it registered a 10.74 percent share of total output 2019.

Five author publications occupy the fourth spot (11.36%) in the list. It was 15.35 percent in the initial year of 2005; finally, in 2019, it registered a 10.74 percent share of total output 2019. The growth of five author contributions shows 111.19 percent variation throughout the period. Single-authored publications occupy the fifth spot with a 10.35 percent share of total output during the period under investigation. Single-author publications registered a 12.38 percent share in the year 2005. Still, it came down to 7.29 percent in the last year, 2019, indicating 93.08 variations in the overall period. It is evident from this analysis that, in total, the growth of publications with more than one author shows an increasing trend during the period under evaluation. It inferred that collaborative research efforts are gaining more momentum during recent years and will continue in future years. Figure 1 shows that among single, two, multi (3&4), and mega (> 4) authored publications, mega-written forms around 42.27 percent, followed by multi-authored publications (31 percent) of the total output. This result assumes that collaborative research effort was predominant among scientists involved in Synthetic Biology research from 2005 to 2019.

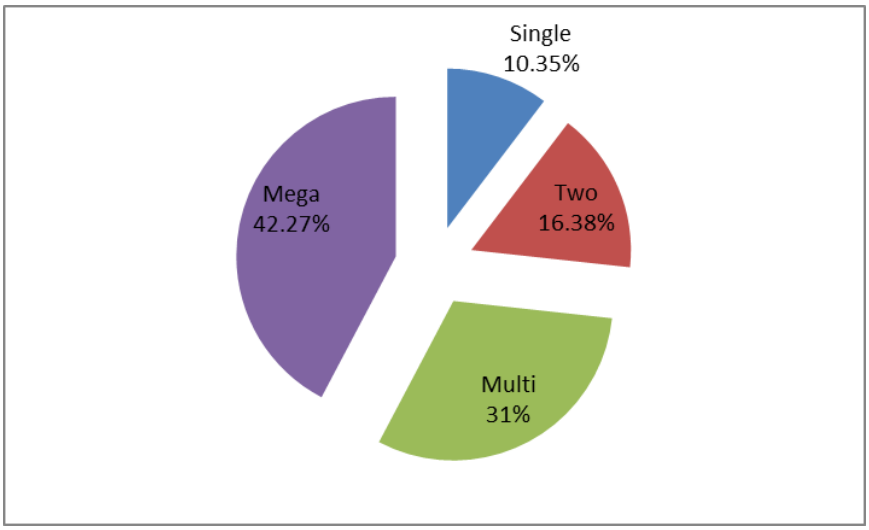

Figure 1: Authorship pattern

5.4 Single Vs. Multiple authorship in Synthetic Biology

Table 5 shows the data about the single and multi-authored publications by year. It can be seen that, in total, multi-authored publications, i.e., 10,769 (89.65%), have an advantage over single-authored publications, i.e., 1,243 (10.35%). The highest number of multi-authored publications, 1,453 (92.78%) observed in 2018, while the lowest was in 2009, i.e., 344 (84.52%). Concerning single-authored publications, the highest number of publications, 63 (15.48%), were found in 2009, while the lowest number, 113 (7.22%), was in 2018.

Table 5: Year-wise Distributions of Single Vs. Multiple Authored Publications

Year	No. of Single Authored publications	%	No. of Multi Authored publications.	%	Total
2005	25	12.38	177	87.62	202
2006	25	10.29	218	89.71	243
2007	29	11.28	228	88.72	257
2008	42	12.96	282	87.04	324
2009	63	15.48	344	84.52	407
2010	74	14.48	437	85.52	511
2011	79	13.50	506	86.50	585
2012	109	13.75	684	86.25	793
2013	97	11.58	741	88.42	838
2014	106	10.86	870	89.14	976
2015	124	10.88	1,016	89.12	1,140
2016	138	10.11	1,227	89.89	1,365
2017	107	8.43	1,163	91.57	1,270
2018	113	7.22	1,453	92.78	1,566
2019	112	7.30	1,423	92.70	1,535
Total	**1243**	**10.35**	**10,769**	**89.65**	**1,2012**

It is evident from Figure 2 that the year-wise comparative analysis showcases the collaborative research effort among scientists who are working on Synthetic

biology research across the globe. Multi-authored publications have a considerable edge over single-authored publications throughout the period under study.

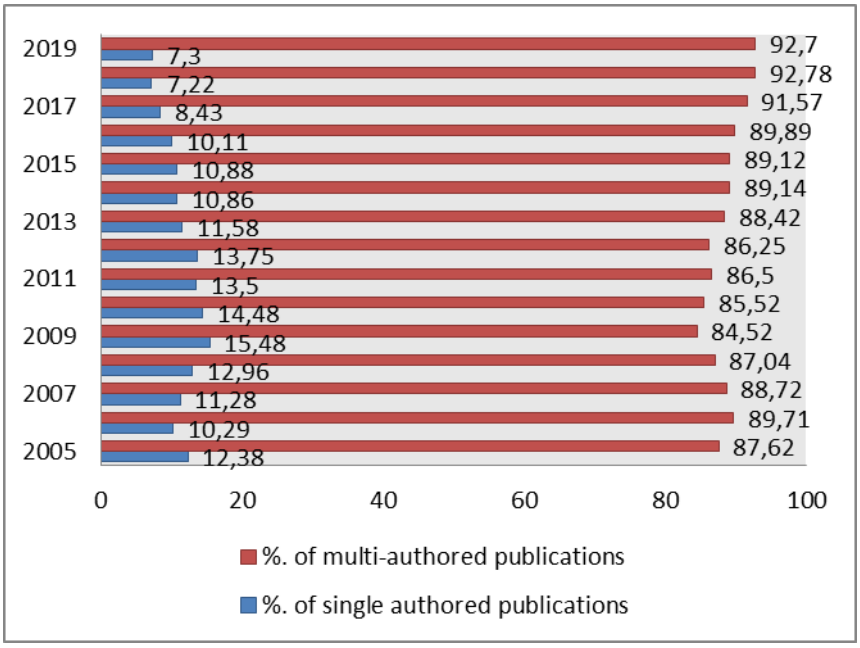

Figure 2: Comparison of Single and Multi-authored Publications in Synthetic Biology

5.5 Correlation between Number of Publications and Multi-authored Publications

Pearson Correlation coefficient was employed to check whether there is any correlation between the total number of publications and multi-authored publications. Table 6 illustrates the results of this test. It is observed that there a strong positive correlation ($r = .999$, $N = 15$, $p = 0.000$) exists between total publications and multi-authored publications. As the p-value is < 0.05 and the r-value (0.99) is nearer to +1, and it is highly significant. Hence it is concluded that there exists a strong positive correlation between total publication output

and multi-authored articles. It means that there is simultaneous growth in total publications and articles. These two variables are highly correlated.

Table 6: Correlation between the Number of Publications and Multi-authored Publications

		Number of publications	Number of multi-authored publications
Number of publications	Pearson Correlation	1	.999**
	Sig. (2-tailed)		.000
	N	15	15
Number of multi-authored publications	Pearson Correlation	.999**	1
	Sig. (2-tailed)	.000	
	N	15	15

Table 6: Correlation between the Number of Publications and Multi-authored Publications

		Number of publications	Number of multi-authored publications
Number of publications	Pearson Correlation	1	.999**
	Sig. (2-tailed)		.000
	N	15	15
Number of multi-authored publications	Pearson Correlation	.999**	1
	Sig. (2-tailed)	.000	
	N	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

5.6 Measures of Collaboration

Measuring the scientific cooperation of authors is one of the essential concepts of Scientometric evaluation. Collaboration happens when two or more authors research the same topic and publish papers with joint authorship. To measure collaboration, various indicators had employed. One can identify the extent of collaboration in a specific field or a year through measures like Collaborative Index (Lawami, 1980), Degree of Collaboration (Subramanyam, 1983), Collaborative Coefficient(Ajiferuke et al., 1988), and Modified Collaborative Coefficient (Savanur & Srikanth, 2010). Adopting these indicators, the extent of collaboration of authors in Synthetic Biology literature from 2005 to 2019 was analyzed, and the results were presented in Table 7

5.6.1 Collaborative Index (CI)

Collaborative Index (CI) is a "measure of the mean number of authors. It is easily computable, but it is not interpretable as a degree. It has no upper limit. Moreover, it gives a non-zero weight to single-authored papers, which involve no collaboration" (Patel, 2020). The following formula is adopted for the calculation of the Collaborative Index:

$$CI = \frac{\sum_{j=1}^{A} \cdot = jfj}{N}$$

Where fj = the number of papers having *j* authors in collection *k*, *N* = the total number of papers in *k*. *N*= ∑ *jfj* ; and *A* = the total number of authors in collection *k*. The results indicate that the CI was at a maximum (5.2326) in 2019 and a minimum (4.0074) in 2009. The mean CI during the study period was 4.5576 (Table 7), indicating a better collaboration rate among the authors in synthetic biology.

5.6.2 Degree of Collaboration (*C*)

The Degree of Collaboration is a measure of the proportion of multiple-authored papers. "It is easy to calculate and interpret as a degree (between 0 and 1). It gives zero weight to single-authored publications and consistently ranks a discipline (or period) with a higher percentage of multiple-authored publications. However, the Degree of Collaboration does not differentiate among levels of multiple authorships" (Savanur & Srikanth, 2010). The Degree of Collaboration among authors is calculated using the following formula:

$$DC = 1 - \frac{fl}{N}$$

This can be expressed as

$$C = \frac{Nm}{Nm+Ns}$$

Where C = degree of collaboration, Nm = number of multiple-authored publications, and Ns = number of single-authored publications. It can be seen from Table 7 that DC was highest at 0.9278 in 2018 and lowest at 0.8452 in2009. It is oblivious from Table 7 that multiple authors authored a significant portion of publications in 2018; hence the highest DC value was recorded in that particular year. Similarly, other years, viz, 2017 and 2019, also recorded the highest value. The mean DC during the period was 0.8863. It clearly shows that there are more publications and a higher level of collaborative research in synthetic biology.

5.6.3 Collaborative Coefficient (CC)

The collaborative Coefficient is "a measure of collaboration in research that reflects both the mean number of authors per paper and the proportion of multi-authored papers. It lies between the values of 0 and 1, and is 0 for a collection of single-authored papers; it is not 1 for the case where all the papers all papers are maximally authored" (Savanur & Srikanth, 2010). In other words, suppose if a paper has a single author; the author receives one credit; if two, each receives ½ credit. The Collaborative Coefficient (CC) can be mathematically expressed as:

$$CC = 1 - \frac{\sum_{j=1}^{A} (1/j)\, fj}{N}$$

"Where *fj* is the number of j-authors research papers published in the discipline during a certain period, *N* is the total number of research papers published in the discipline during a certain period (excluding anonymous authors), and *K* is the greatest number of authors per paper in a discipline" (Ajifeurke et al., 1988). It is found in Table 7 that CC was highest at 0.6991 in 2018 and lowest at 0.6079 in 2009. The mean value of CC during the period was 0.6079, indicating better collaboration rates among the authors in the field.

5.6.4 Modified Collaborative Coefficient (MCC)

The Modified Collaborative Coefficient is "almost equivalent to that of the Collaborative Coefficient. Imagine that each paper carries with it a single "credit" this credit is being shared among the authors" (Savanur & Srikanth, 2010). Modified Collaborative Coefficient (MCC) can be mathematically expressed as:

$$MCC = \frac{A}{A-1}\{1 - \frac{\sum_{j=1}^{A} \left(\frac{1}{j}\right) fj}{N}\}$$

"Where A is a normalization constant to be determined, setting A = 1 yields the measure CC. The requirement that j = 0 for single authorship does not restrict. The above equation is not defined for the trivial case when A = 1, which is not a

problem since collaboration is meaningless unless at least two authors are available. CC approaches MCC only when A → ∞ but is otherwise less than MCC by the factor 1-1/A" (Kumar et al., 2020). It is found in Table 7 that MCC was highest at 0.6995 in 2018 and lowest at 0.6094 in 2009. The mean MCC during the period was 0.6495, which is highly significant and represents better authorship collaborations.

Table 7: Measures of Collaboration in Synthetic Biology Literature

Year	***CI***	***DC***	***CC***	***MCC***	***MCC-CC***
2005	4.5396	0.8762	0.6441	0.6473	0.0032
2006	4.4321	0.8971	0.6567	0.6594	0.0027
2007	4.3230	0.8872	0.6426	0.6452	0.0025
2008	4.4352	0.8704	0.6265	0.6285	0.0019
2009	4.0074	0.8452	0.6079	0.6094	0.0015
2010	4.1566	0.8552	0.6098	0.6110	0.0012
2011	4.2496	0.8650	0.6215	0.6226	0.0011
2012	4.1412	0.8625	0.6152	0.6159	0.0008
2013	4.5167	0.8842	0.6438	0.6446	0.0008
2014	4.5512	0.8914	0.6505	0.6512	0.0007
2015	4.6825	0.8912	0.6565	0.6570	0.0006
2016	4.8066	0.8989	0.6645	0.6650	0.0005
2017	5.1299	0.9157	0.6882	0.6887	0.0005
2018	5.1596	0.9278	0.6991	0.6995	0.0004
2019	5.2326	0.9270	0.6972	0.6976	0.0005
Mean	**4.5576**	**0.8863**	**0.6483**	**0.6495**	**0.0013**
Max	**5.2326**	**0.9278**	**0.6991**	**0.6995**	**0.0032**
Min	**4.0074**	**0.8452**	**0.6079**	**0.6094**	**0.0004**

As shown in Table 7, there was only a meager difference between the values of CC and MCC throughout the period under study. The highest difference (0.0032) between CC and MCC was observed in 2005, while the lowest (0.0004) was in 2018. In 2005, the total number of authors was 917, the weakest

of all years of understudy in both publications and contributing authors. Hence it can be inferred from the results that there is no significant variation between the values of CC and MCC. It also noted that this variation narrowed down when the number of authorships increased.

5.8 Pattern of Co-authorship in Different Years

The co-authorship index (CAI) is one of the main indexes used for analyzing author collaboration patterns. This index can obtain by calculating the number of single, two, multi-, and mega-authored publications proportionally for different nations or subjects or years (Schubert and Braun, 1986; Garg and Padhi, 2001). The pattern of co-authorship for various years in Synthetic Biology literature is tabulated and presented in Table 8 (Annexure-2). The Co-authorship Index (CAI) values regarding single-authored, two-authored and multi-authored publications showed an inconsistent trend from 2005 to 2019. They showed a declining trend during the last three years. However, mega-authored publications revealed a clear reverse direction compared to single, two, and multi-authored publications, indicating an increasing trend over the years. Interestingly, mega-authored publications gained momentum in the last four years, i.e., from 2016 to 2019. At the same time, CAI values of single, two, and multi-authored publications showed a declining trend during these four years. The CAI values of single-authored publications varied from 69.73 to 149.59. The highest value (149.59) was exhibited in 2009, and the lowest (69.73) was observed in 2018. CAI values of two authored publications varied between 82.67 to 124.4. The highest value (124.4) was observed in 2008, and the lowest (82.67) followed in 2018. CAI values of multi-authored publications varied between 89.89 to 111.7. The highest value (111.7) was observed in 2007, and the lowest (89.89) was observed in 2014. CAI values of mega-authored publications varied between 78.45 to 116.04. The highest value (116.04) was observed in 2019, and the lowest value (78.45) was observed in 2012. It is

inferred from the results that the proportion of multi-authored publications during the last four years, i.e., 2016 to 2017, is much higher than the average for all years during the period under evaluation. Hence, the collaborative research effort has gained more momentum in the Synthetic Biology discipline worldwide in recent years.

5.9 Most productive authors in Synthetic Biology

Author analysis showed that 33151 unique authors contributed to Synthetic Biology literature during the study period. The top ten prolific authors are based on the number of publications illustrated in Table 9.

Table 9: Most Productive Authors in Synthetic Biology Literature

Sl.no	Name	No. of Publications	% of publications	Affiliation
1	Fussenegger M	118	0.98	Swiss Fed Inst Technol (ETH), Switzerland
2	Keasling JD	80	0.67	Univ Calif Berkeley, USA
3	Zhao, Huimin	62	0.52	Univ Illinois, USA
4	Weber, Wilfried	57	0.47	Swiss Fed Inst Technol, Switzerland
5	Voigt CA	54	0.45	MIT, USA
6	Chen, Jia	53	0.44	China Agr Univ, China
7	Lu, Timothy K	53	0.44	MIT, USA
8	Collins JJ	52	0.43	MIT/Wyss Institute, USA
9	Jewett, Michael C	50	0.42	Stanford Univ, USA
10	Wang Y	50	0.42	Virginia Polytech Inst & State Univ, USA

The top author's list included seven authors from the USA, two from Switzerland, and one from China. It is found that Fussenegger M of *Swiss Federal Institutes of Technology* (ETH), Switzerland leads the list with 118 publications, followed by Keasling JD of *the University of California, Berkeley*, USA, with 80 publications, Zhao HM of *the University of Illinois*, the USA with

62 publications. Of these top 10 authors, three authors are affiliated with MIT, USA.

5.10 Co-authorship Network Visualization of Authors

Figure 3 shows the co-authorship network visualization map of top authors in Synthetic biology—documents with more than 25 authors omitted from this analysis. The researcher included authors with a minimum of 35 articles in network generation. Based on these criteria, the researcher chose 51 authors for the study. Figure 3 shows the research connectivity of these authors in the form of links. Each circle represents each author. These 51 authors clustered according to their close collaboration with each other.

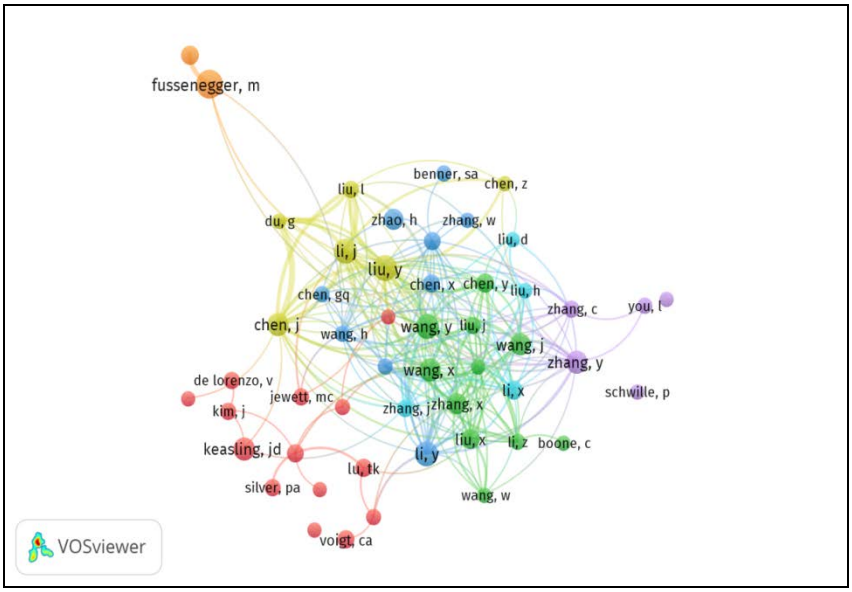

Figure 3: Co-authorship Network Visualization of Authors

It can be seen from Figure 3 that there are seven different clusters in the network map. The first cluster (red color) consisted of 14 authors. The second cluster (green color) consisted of 11 authors. The third cluster (blue color) consisted of 9 authors. The fourth cluster (yellow color) consisted of 6 authors. The fifth

cluster (purple color) consisted of 5 authors. The sixth cluster (light blue color) consisted of 4 authors, and the seventh cluster (orange color) consisted of 2 authors. It was evident from these clusters that Chinese authors maintain good connectivity in research activities. Liu, Y obtained the highest link strength (146), followed by Li, J and Chen, J with a link strength of 131 each, and Liu, L with a link strength of 97. This network shows strong collaboration among the following authors: Du, G – Chen, J (link strength =35), Weber, W – Fussengger, M (link strength= 21), Liu, J – Li, J (link strength = 20), Du, g –Li, J (link strength = 15) and Du, g – Liu, L (link strength = 13).

6. Conclusion

The publication trend can be better visualized in scientometric-based research through author collaborations. The study provides a complete view of authorship and collaborative patterns of global synthetic biology research. The study's results and findings will help researchers know about the collaborative authorship pattern and correlation metrics and establish directions for future research in the untouched domine of Synthetic Biology. This study finds that the average number of authors per paper in the present data set is 4.56. The average productivity per author is 0.22, which shows that the number of authors is increasing and the number of publications. The current data show a positive correlation between the number of publications and the number of authors. Further, the study finds higher rates of mean values of collaboration indicators (CI = 4.5576, DC = 0.8863, CC = 0.6483, and MCC = 0.6495) also proved the better rates of collaborations among authors in this field. The Co-authorship Index (CAI) values regarding single-authored, two-authored and multi-authored publications showed an inconsistent trend from 2005 to 2019. They showed a declining trend during the last three years. However, mega-authored publications revealed a clear reverse trend compared to single, two, and multi-authored publications, indicating an increasing trend over the years. Multi-

authored publications have a considerable edge over single-authored publications throughout the period under study.

The majority of top authors have affiliated with institutions that originated in the USA. Fussenegger M of the *Swiss Federal Institutes of Technology* (ETH), Switzerland, leads the list with 118 publications, followed by Keasling JD of *the University of California, Berkeley*, USA, with 80 publications. Network visualization analysis of the most prolific authors revealed that Chinese authors maintain good connectivity in research activities. The results of this study will be helpful to a variety of stakeholders in Synthetic biology research, and it also presents some limitations. The research focused on publications from 2005 to 2019, which were indexed in a single database. We suggest that a larger sample of data could be considered for future studies. Likewise, future studies to be addressed the relationship between the number of authors and the academic impact of papers.

References

Ajiferuke, I., Burell, Q., & Tague, J. (1988). Collaborative Coefficient: A single measure of the degree of collaboration in research. Scientometrics, 14(5–6), 421–433. https://doi.org/10.1007/BF02017100

Garg KC and Padhi P. (2001).A study of collaboration in laser science and technology. Scientometrics.415-427.

Hu, X., & Rousseau, R. (2015). From a word to a world: The current situation in the interdisciplinary field of synthetic biology. *PeerJ, 3*, e728. doi:10.7717/peerj.728.

Lawani, S. M. (1980). *Quality, Collaboration And Citations In Cancer Research: A Bibliometric Study* (Order No. 8100645). p 395. Available from ProQuest Dissertations & Theses Global. (302998207). Retrieved from https://elibpondiuni.remotexs.in/user/login=?url=https://www.proquest.com/dissertations-theses/quality-collaboration-citations-cancer-research/docview/302998207/se-2?accountid=51188

Oldham, P., Hall, S., & Burton, G. (2012). Synthetic biology: Mapping the scientific landscape. *PLoS ONE, 7*, e34368.

Patel, R., & Science, I. (2020). *Analysis of Library and Information Science Research From Gender Perspective : a Case Study of Srels Journal of Information Management Analysis of Library and Information Science Research From Gender Perspective : a Case Study of Srels Journal of*. *1600776*.

Paula, M., & Sancho, L. (2021). *Authorship trends and collaboration patterns in hospitality and tourism research*. https://doi.org/10.1108/IJCHM-09-2020-0981

Raimbault B, Cointet JP, Joly PB (2016) Mapping the Emergence of Synthetic Biology. PLOS ONE 11(9): e0161522. https://doi.org/10.1371/journal.pone.0161522.

Savanur, K., & Srikanth, R. (2010). Modified collaborative Coefficient: A new measure for quantifying the degree of research collaboration. *Scientometrics*, *84*(2), 365-371. https://doi.org/10.1007/s11192-009-0100-4.

Schubert A. and Braun, T. (1986). Relative indicators and relational charts for comparative assessment of publication output and citation impact. Scientometrics.,9: 281-291.

Shapira, P., Kwon, S., & Youtie, J. (2017). Tracking the emergence of synthetic biology. *Scientometrics*, *112*(3), 1439-1469. https://doi.org/10.1007/s11192-017-2452-5

Subramanyam, K. (1983). Bibliometric studies of research collaboration: A review. *Journal of information Science*, *6*(1), 33-38.

Wang, F., & Zhang, W. (2019). Synthetic biology: recent progress, biosafety and biosecurity concerns, and possible solutions. *Journal of Biosafety and Biosecurity*, *1*(1), 22-30.

Yoshikane, F., Nozawa, T., Shibui, S., & Suzuki, T. (2009). An analysis of the connection between researchers' productivity and their co-authors' past attributions, including the importance in collaboration networks. *Scientometrics*, *79*(2), 435-449. https://doi.org/10.1007/s11192-008-0429-8

Zafrunnisha, N., & Pullareddy, V. (2009). Authorship pattern and degree of collaboration in psychology. *Annals of Library and Information Studies*, *56*, 255-261.