Research Trends and Hotspots Related to the Natural Sciences in the 21st Century Based on Citespace and VOSviewer Software

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Abstract. Effective policies and rational allocation of resources usually play an important role in the development of science and technology in various fields. To study and judge the trend of future technology development and determine the frontier areas of science and technology will provide scientific basis and important support for the strategic deployment of innovation subjects. In this paper, Citespace and VOSviewer software are used to analyze the variation trend of the number of papers published in different countries and regions, research direction, and the number of papers published by institutions and cooperation. The social network analysis method was used to construct the co-occurrence clustering map of keywords, and Kleinberg's burst detection algorithm was used to analyze the term mutation. The results show that the world's major industrial countries are the main force of global scientific and technological innovation, and China's scientific and technological innovation capability has improved rapidly in the past decade, becoming an important force of global scientific and technological innovation. The research of malignant tumor and artificial intelligence is the hotspot of current research. Cryogenic electron microscopy and RNA interference are the frontier technologies concerned by nature and science. In terms of the number of published papers, scientific and technological innovation activities in the field of life science are very active in the world, and the aggregation effect of national and regional scientific and technological innovation is also very obvious.

A. Luqman et al. (Eds.): PMIS 2022, AHCS 6, pp. 198–214, 2023.
https://doi.org/10.2991/978-94-6463-016-9_24

Keywords: Citespace · VOSviewer · Social network analysis · Kleinberg's burst detection

1 Introduction

Nature was founded by Macmillan Publishing Co., Ltd. in 1869. It is the earliest international scientific journal in the world [1, 3]. It has published many important papers in the history of science, such as the DNA double helix structure [30], the discovery of pulsar [12], and the clone of Dolly the sheep [31]. Science was founded in 1880 by the world-renowned scientist and inventor Thomas Alva Edison [3, 21]. It is now sponsored by the American Association for the Advancement of Science [27]. It has published breakthrough research results such as high-temperature superconductors [33] and AIDS research [13], and has played an unparalleled role in the development of world science newspapers and magazine [24, 32]. Nature and Science are recognized as the most authoritative comprehensive scientific journals in the international academic community [15, 24], which mainly publish the most cutting-edge and most important original scientific research and research reviews in various research fields [23]. They are the vane of scientific research and have always reported on the scientific community. The mission is to make major discoveries and important breakthroughs. They are the forefront of scientific research results reports, with the eternal pursuit of exploring the mysteries of nature, understanding natural phenomena, and mastering the laws of nature. Scientists in the fields of biomedicine and life sciences in the world today regard their articles published in Nature and Science as important signs of their recognition by international peers [16]. Articles published in Nature and Science have also been widely cited and paid attention to by the scientific community. These two journals which the literature published on has a very high level of innovation and leading value; at the same time, bibliometric indicators such as the distribution of publishing organizations, the amount of articles, and the mutation of terminology have a very high reference for studying the distribution of global scientific and technological innovation capabilities and understanding the frontiers and hotspots of global science and technology value.

In today's world, scientific and technological innovation is the strategic support for the country's comprehensive national strength and social productivity [35]. Major economies around the world have increased their investment in scientific and technological research and development, and the output of documents in various disciplines has also grown rapidly. Relying only on reading or qualitative research, it is difficult to objectively and accurately reveal the overall picture of the development of various disciplines. Bibliometrics can solve this problem by quantitatively analyzing various descriptive fields in the literature. Combined with the related theories and methods of information visualization, the bibliometrics methods is constantly innovating and revitalizing itself, and is widely used in scientific knowledge discovery [8], scientific and technological frontier identification [29, 34], scientific evaluation [14] and other fields. The literature search results show that there are few bibliometrics researches based on the articles published in Nature and Science magazines. Two literature reports in the 1980s, due to the limitations of the research tools and methods at the time, the author of

the literature used the statistical method of the number of articles to analyze and compare the average number of authors per paper, the national distribution of the first author, and the discipline distribution of the first author in the 153 and 152 papers published in Nature and Science magazines from 1981 to 1983 [15]; Another author analyzed and compared Nature and Science magazines from 1981 to 1985 using the statistical method of the number of articles published, and the author's country and region distribution and impact factors [3]. Entering the 21st century, Nature magazine analyzed the archives of Nature magazines since 1869 and conducted a statistical analysis. The results show that the early research contributions of all disciplines were average, but biomedicine has become prominent in the past century, and it is also found that the proportion of female authors is increasing [19]. There is also a literature author using the method of co-occurrence network analysis of citations to study the large number of citations of Nature papers by academic papers in the subject field, showing that Nature magazine has a wide range of influence [10]. There is also an editorial on the scientific profession published by the author in Nature and Science magazines from 2000 to 2012 [27]. The author also studied the relationship between the empirical data and theoretical conclusions of experimental psychology articles published in the journal Science in the field of psychology during 2005–2012 [9]. It can be seen that there is no report on the bibliometrics research on the characteristics of the articles published in Nature and Science by the use of bibliometrics methods such as word frequency mutation and co-occurrence analysis.

Based on the Web of Science database platform, this study collected all the bibliometrics data published in Nature and Science journals from 2001 to 2020, and applied the latest bibliometrics methods and tools. Using the latest bibliometrics methods and tools, the authors quantitatively analyzed the characteristics of national and regional distribution, institutional and cooperative research analysis, and keyword co-occurrence analysis of the articles published in Nature and Science over a long time span, in order to reveal the preference of the articles published in Nature and Science. The analysis of the results will provide a strong support for the general public, policy makers and researchers to understand the characteristics of the articles published in Nature and Science. Meanwhile, it will also discuss the hot spots and evolution of global scientific research, so as to provide a reference for government departments to formulate Science and technology policies and rationally allocate limited Science and technology resources.

2 Data Sources and Research Methods

2.1 Data Sources

Nature and science are internationally recognized top comprehensive journals, and the articles published in these two journals represent the most cutting-edge and innovative research in this field. The bibliometrics research on the articles in these two journal scan help us understand the hot countries and regions of scientific and technological innovation as well as the global scientific and technological frontier and hot spots more quickly and accurately. In this paper, Web of science is used as the data source and searches with "SO = ("Nature")" and "SO = ("Science")" as the search terms. The publication time is limited to 2001–2020, the document type is limited to "article", and the retrieval

time is October 7, 2021. Download the data in the form of "full records and citation references" and import it into Citespace for format conversion. After preprocessing steps such as deduplication, cleaning, and sorting, the number of publications in Nature and Science will be 17,803 and 15,941 respectively. Article title information, each piece of information includes Wos accession number, Wos subject classification, co-author, author address and other field information. Use the transformed data as the data source of this research as the source of this research data, and re-import it Perform corresponding analysis in VOSviewer [25, 26, 28] and Citespace [4–6], and obtain various analysis and visualization knowledge graphs.

2.2 Research Methods

This article adopts the method of bibliometrics to analyze and research literature data. The research methods of scientometrics are widely used to explore the quantitative relationship, research status, development context and future trends of a certain research field. The essence of scientometrics can be attributed to two categories: statistical analysis methods and co-occurrence analysis methods. Statistical analysis methods generally include metadata statistics and influence statistics. Co-occurrence analysis methods include cooperative analysis, co-citation analysis, and coupling analysis. At present, the most widely used visual analysis tool in the field of information co-occurrence analysis is Citespace. The software is a diversified, time-sharing, and dynamic scientific literature analysis tool developed under the background of scientometrics, data and information visualization; another bibliometric tool used in this study is VOSviewer, which is a document analysis and knowledge visualization software. It has unique advantages in literature keyword analysis, cluster analysis, topic words, author information, etc. The software also has more prominent advantages in processing big data, rendering, and images, and can more clearly show hotspots and topics in the research field. CiteSpace focuses on showing the strength of each topic relationship with tree diagrams and links, while VOSviewer mainly uses distance and density to deconstruct the clustering relationship between nodes. Both have complementary advantages and can accurately dig out the essence of the research topic.

3 Results and Analysis

3.1 Global Publication Share and Ranking

We counted the 10 countries with the most articles published in Nature and Science magazines from 2001 to 2020 in 2015–2020. From Table 1, it can be seen that the United States, Germany, and England ranked in the top three in the four time periods of 2001–2005, 2006–2010, 2011–2015 and 2015–2020. From the data in Table 1, it can be seen that the proportion of American posts has been ranked first, the proportion of posts issued by Germany and England has increased year by year, and the proportion of posts issued by 2015–2020 has exceeded 21%; the proportion of posts issued by China from 2001–2005 Increased from 2.12% to 15.58% in the period of 2015–2020; the ranking of posts increased from 13th to 4th; the number of posts increased from 198 in 2001–2005 to 20015–2020. 1258 articles, an increase of nearly 60%.

Table 1. The top 10 countries (regions) in the number of articles published in Nature and Science magazines from 2001 to 2020 (Photo credit: Original)

Country	Number of papers (share of papers, %)							
	2001–2005		2006–2010		2011–2015		2015–2020	
USA	6238	66.65	5856	70.68	5758	71.74	5724	70.89
GERMANY	1377	14.71	1378	16.63	1491	18.58	1757	21.76
ENGLAND	1086	11.60	1226	14.80	1490	18.57	1709	21.16
PEOPLES R CHINA	198	2.12	321	3.87	644	8.02	1258	15.58
FRANCE	778	8.31	819	9.89	940	11.71	971	12.03
SWITZERLAND	381	4.07	467	5.64	636	7.92	828	10.25
JAPAN	744	7.95	728	8.79	687	8.56	783	9.70
CANADA	498	5.32	577	6.96	709	8.83	697	8.63
AUSTRALIA	308	3.29	371	4.48	534	6.65	647	8.01
NETHERLANDS	356	3.80	375	4.53	528	6.58	576	7.13

The member states of G7 include: the United States, the United Kingdom, France, Germany, Japan, Italy, and Canada. They are the world's major industrial countries. At the beginning of their establishment, their economies accounted for 65% of the global economy. We can see that the number of publications in Nature and Science magazines in the other 6 countries except Italy ranks among the top 10.In addition, China's economic aggregate in 2001 accounted for 4.14% of the global economy, and its economic aggregate in 2020 accounted for more than 17% of the global economy. In the past 20 years, the economy has achieved rapid economic development. At the same time, we can also see that during the 20 years, the number of high-level articles published in two top comprehensive magazines in the world has also achieved leapfrog development. This shows that high-level scientific research needs to be strong. It can be inferred from this that high-level scientific research requires strong economic strength to support it and provide adequate funding guarantees.

3.2 The Amount of Papers Published in the Research Direction and the Trend of Change

The author counted 145 research directions in the web of Science database. According to the subject category of the Web of Science database, the papers belonging to the Biochemistry Molecular Biology research direction accounted for the highest proportion, accounting for 7.39%, followed by the papers of Genetics Heredity research direction, accounting for 6.21%, and the third-ranked research direction is Cell Biology research papers, accounting for 4.40%.We took the number of articles published in Nature and Science magazines during the period from 2001 to 2005 as the reference object, and calculated the rate of change in the proportion of articles published in each research direction during the period 2006–2010, 2011–2015, and 2016–2020. We study the trend

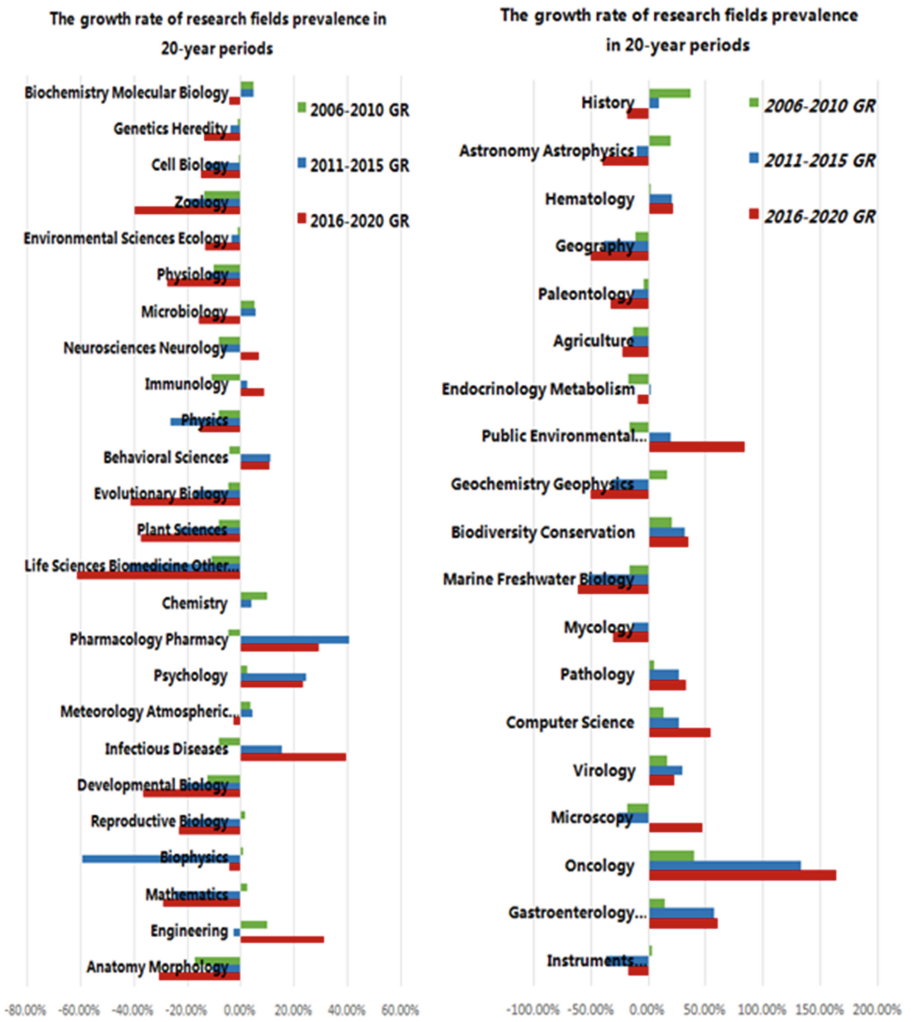

Fig. 1. The growth rate of research fields prevalence in 20-year periods (Rank 45) (Photo credit: Original)

of changes in a total of 45 research directions in Nature and Science magazines that accounted for more than 0.5% of the articles in the past 20 years. As can be seen from Fig. 1, during the 2016–2020 period, Oncology, Public Environmental Occupational Health, Gastroenterology Hepatology, these three research directions accounted for the largest growth rates, which were 163.91%, 84.78%, and 60.88% respectively; Oncology, Gastroenterology Hepatology, Computer Science, pathology, Biodiversity Conservation, these 5 research directions have maintained continuous growth for 3 consecutive statistical periods; Infectious Diseases, Engineering, Immunology, Neurosciences Neurology,

Public Environmental Occupational Health, these five research directions, the percentage growth rate of articles in the 2016–2020 time period has increased significantly compared with the 2011–2015 time period.

Malignant tumors are diseases that seriously threaten human life and health. In addition to biological factors such as genetics, lifestyle and environmental factors are important causes of malignant tumors. In response to the problem of malignant tumors, major European and American countries have implemented national-level malignant tumor (cancer) scientific and technological research plans to study the etiology and pathogenesis of cancer, precision diagnosis and treatment technology and drugs, cancer prevention and control big data research, etc. With the improvement of human rights and health awareness in various countries, the state-led scientific research investment organizes scientific research personnel to conduct organized scientific research, and the output of high-level achievements such as Nature and Science has also increased year by year in the three time periods of 2006–2010, 2011–2015, and 2016–2020. In the 21st century, information technology has penetrated into every field of economic and social development. The industrial revolution led by technologies such as the Internet, big data, and artificial intelligence is developing rapidly, and the application of technologies such as autonomous driving, artificial intelligence, and quantum computing has been fully developed. Therefore, the research direction of Computer Science is also a hot direction for researchers to produce original innovative results.

3.3 Analysis of Institutions and Their Cooperation

Table 2 shows that 8 of the 10 most productive institutions for Nature and Science magazines are from the United States, such as Harvard University, the University of California System, National Energy Center, etc., and the other 2 are from France's National Scientific Research Center and Germany's Max· The Planck Society shows that developed countries such as the United States, France, and Germany have made outstanding contributions to global basic research and original innovation. The University of California has the highest number of publications, with a total of 5,158 papers, and the highest number of citations, with a total of 17,64078, and the H index, with the highest number of 643. However, the average number of citations is less than that of Harvard University. MIT ranks sixth in the number of articles published and fourth in the number of citations, but the average number of citations is 435.85, ranking first among all institutions; It can be seen that the Massachusetts Institute of Technology has the largest average global influence on a single paper in Nature and Science.

Using the VOSviewer software to analyze all the papers in Nature and Science magazines with the document type of "Article" from 2001 to 2020, it shows that there are 14863 institutions in total; we choose "Minimum number of documents of an organization" as 50, showing that there are 433 institutions, the cooperative relationship among these institutions is shown in Fig. 2. It can be seen from the figure that 433 institutions are divided into 6 clusters based on the closeness of cooperation: The first category (cluster #1) with red icons in the figure is centered on Univ. Oxford. Including 194 institutions, such as Univ. Cambridge, Univ. Edinburgh, Univ. Hamburg, Univ. Helsinki and other universities, have a connection strength of 2873; the second category (cluster #2) with a green icon in the figure is centered on Univ. Calif. Berkeley, including 91 institutions,

Table 2. The top 10 high-yield institutions in Nature and Science magazines from 2001 to 2020 (Photo credit: Original)

Rank	Institutions	Nation	TP	TC	AC	HI
1	UNIVERSITY OF CALIFORNIA SYSTEM	USA	5158	1764078	342.01	643
2	HARVARD UNIVERSITY	USA	3643	1542695	423.47	637
3	HOWARD HUGHES MEDICAL INSTITUTE	USA	3007	1118801	372.07	542
4	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	France	2384	657789	275.92	404
5	MAX PLANCK SOCIETY MASSACHUSETTS	Germany	2138	630368	294.84	400
6	INSTITUTE OF TECHNOLOGY	USA	2031	885205	435.85	487
7	UNITED STATES DEPARTMENT OF ENERGY	USA	1891	702650	371.58	429
8	STANFORD UNIVERSITY	USA	1707	629160	368.58	405
9	UNIVERSITY OF CALIFORNIA BERKELEY	USA	1560	557209	357.19	383
10	CALIFORNIA INSTITUTE OF TECHNOLOGY	USA	1265	310764	256.66	298

Note: TN = total number; TP = total percent; TC = total citation; AC = Average citation; HI = h-index

such as Johns Hopkins university, Princeton, Caltech and other universities; the third category (cluster #3) with a sky blue icon in the figure is centered on Harvard Univ. as the center, including 72 institutions, such as MIT, Stanford Univ., Yale Univ., Columbia Univ. and other universities; the fourth category (cluster #4) with a yellow icon in the figure is centered on Univ. British Columbia, including a total of 31 institutions, such as Univ.Toronto, Mcgill Univ., Mcmster Univ., Univ. Ottawa, Univ. Montreal; the fifth category (cluster #5) with a purple icon in the figure is centered on Univ. Tokyo, including a total of 22 institutions, such as Kyoto Univ., Osaka Univ., Tohoku Univ., Seoul natl. Univ., Nagoya Univ.; the sixth category(cluster #6) with a turquoise blue icon in the figure is centered on Chinese acad. sci., including 22 institutions, such as Tsinghua Univ., Peking Univ., Univ.Chinese acad. sci. and other universities.

From the above analysis, we can see that through VOSviewer cluster analysis, the cooperative units that publish articles in the world-recognized top comprehensive magazines of Nature and Science have the following characteristics: (1) The clustering effect of cooperative units is obvious by countries and regions, such as the first category. Mainly Europe, Britain, Germany, Finland and other countries; the second and third categories are mainly the United States; the fourth category is mainly based on Canada; the fifth category is mainly based on East Asian countries such as Japan and South

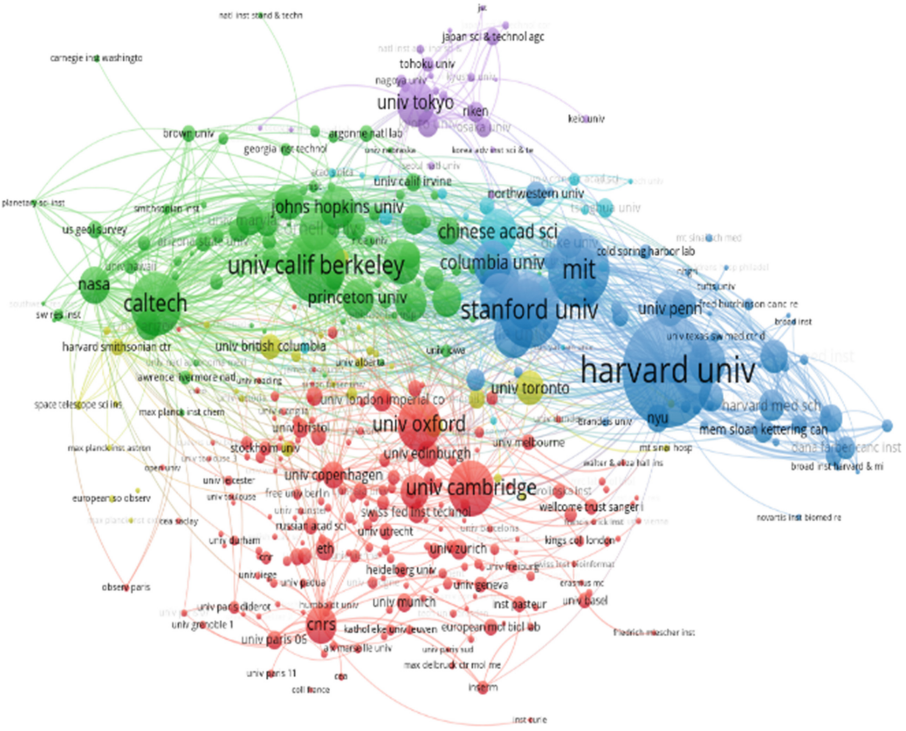

Fig. 2. Analysis of the relationship map of the cooperating institutions published in Nature and Science magazines from 2001 to 2020 (Photo credit: Original)

Korea; The six categories are mainly based on Chinese universities; (2) The cooperative institutions have some administrative scientific research institutions, such as NASA, Chinese acad. sci. and other institutions, but the main bodies of publications in Nature and Science magazines are universities; it can be seen that universities are still the main bodies of original innovation Power and an important birthplace; (3) European, American, Japanese and other developed countries have a dominant position in the number of publications in Nature and Science magazines, and their original innovation capabilities are strong. At the same time, China's publication volume in Nature and Science magazines has grown rapidly in recent years, and Chinese researchers have gradually formed a relatively prominent innovative force.

3.4 Keyword Co-occurrence Cluster Analysis

Keywords are the condensed core ideas of the article. Research on keywords in a field can quickly grasp the research hot spots in this field (Chen, 2010). In the analysis network, the node size reflects the total frequency of occurrence of a certain keyword. The higher the frequency of occurrence, the larger the node. The distance between keywords reflects the degree of intimacy between words. The closer the relationship, the closer the distance, and vice versa, the farther the distance. The distance between keywords reflects the degree of intimacy between words. The closer the relationship, the closer the

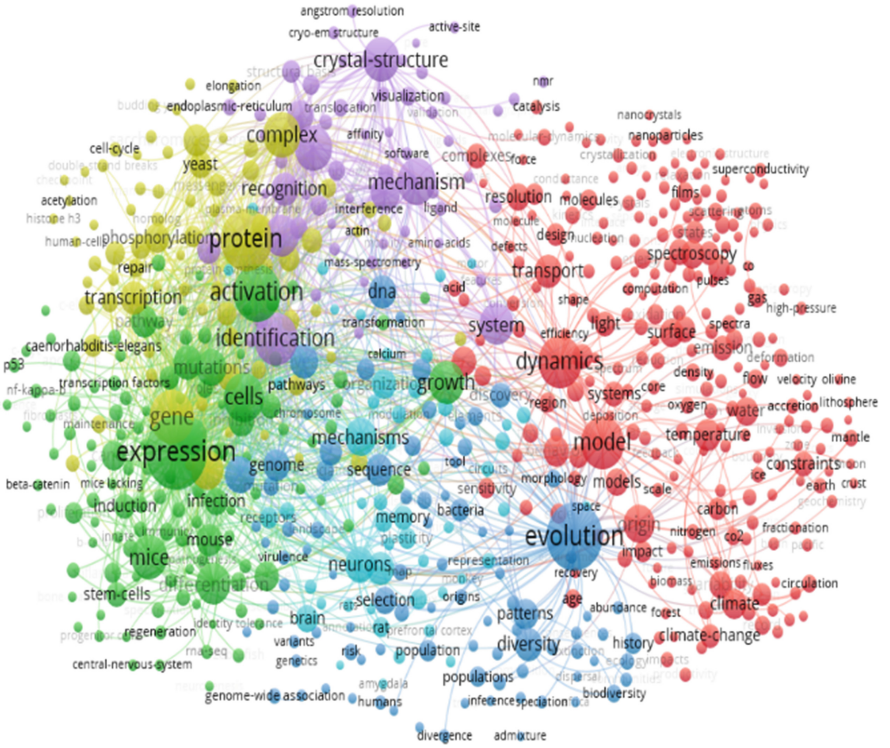

Fig. 3. Analysis of the co-occurrence map of key words published in Nature and Science magazines from 2001 to 2020 (Photo credit: Original)

distance, and vice versa, the farther the distance. Imported 17803 papers in Nature and 15941 Science papers into the VOSviewer software, extracted keywords Plus, a total of 51038 keywords, according to the minimum frequency of 50 occurrences, a total of 643 keywords were selected. A map of the keyword research hotspots of articles published by Nature and Science from 2001 to 2020 is drawn, as shown in Fig. 3. The first theme is "Atmospheric Environmental Research" with a total of 246 keywords, such as water, temperature, Antarctica, the greenhouse effect, and climate change; the second theme is "Disease-related research" with a total of 119 keywords, such as Alzheimer's disease, tumors, breast cancer, diabetes, and pathology, gene expression and signal pathways; the third theme is "Biodiversity Research" with a total of 90 Keywords, such as ecology, environment, population, protection, extinction, landscape, evolution, natural selection; the fourth theme is "Molecular, Cell Biology Research" with a total of 75 keywords, protein, cell cycle, DNA, RNA, antibody, DNA methylation, DNA damage, gene expression, information transmission, transcription, transport, etc.; the fifth theme is "structure-based molecular mechanism research" with a total of 61 keywords, crystal structure, mechanism of action, domain, active site Points, ion channels, mutations, cell membranes, structural basis; the sixth theme is "brain science related research" with a

total of 52 keywords, such as amygdala, cerebral cortex, interneurons, hippocampus, neural circuits, brain damage, memory, Plasticity, reward mechanism, etc.

3.5 Analysis of Mutation Terms

Abrupt term refers to a professional term that changes suddenly within a discipline, which manifests as a sudden increase in published literature in certain years, and can be used to characterize research frontiers. Kleinberg's Burst Detection algorithm is commonly used to detect mutation terms. This algorithm focuses on words with a sudden increase in relative growth rate and models the frequency of words in different time periods based on probability machines. In a sense, the greater the burst weight, the higher the credibility of the burst. Therefore, Kleinberg's mutation detection algorithm can be used to detect mutation terms, and the mutation weight of mutation terms can analyze and judge the research frontier of the field. In this study, Citespace software that supports mutation Detection was used, and its Burst Detection module used Kleinberg algorithm for mutation Detection, which can detect the sudden increase of research interest in a certain field over a period of time.

The mutation terms published in Nature and Science magazines from 2001 to 2020 were tested respectively. The model parameters were default values. A total of 30 mutation terms were detected. From 2001 to 2020, it can be seen from Fig. 4 that the top ten mutation terms in the order of mutation degree in Nature magazine are: cryo-electron microscopy structure (mutation intensity: 40.04), mouse model (mutation intensity: 24.91), degrees C (mutation intensity: 22.89), cryo-electron microscopy (mutation intensity:: 21.81), tumour growth (mutation intensity: 21.2), cancer cells (mutation intensity: 20.29), embryomic stem cells (mutation intensity: 19.8), degrees celsius (mutation intensity: 17.2), RNA interference (mutation intensity: 15.98), cryo-em structure (mutation intensity: 14.87). It can be seen from Fig. 5 that the top ten mutation terms in the ranking of mutation degrees in Science magazine are: cryo-electron microscopy structure (mutation intensity: 24.68), cryo-electron microscopy (mutation intensity: 16.6), RNA interference (mutation intensity: 13.56), time scales (mutation intensity: 11.22), drosophila melanogaster (mutation intensity: 10.95), many-boby system (mutation intensity: 10.95) Intensity: 10.89), cancer cells (mutation intensity: 10.81), caenorhabditis elegans (mutation intensity: 9.81), cell type (mutation intensity: 9.18), major challenge (mutation intensity: 9.17). We can see that the top ten common mutation terms in Nature and Science magazines are: cryo-electron microscopy structure, cryo-electron microscopy, and RNA interference, indicating that these three mutation terms are hot words shared by Nature and Science magazines. The author's access to relevant information shows that: low-temperature electron microscopy technology can image a variety of protein conformations and help scientists infer protein functions [20]. In the future, it will become the mainstream choice for protein structure analysis [17], and it will become the mainstream of structural biology [18]. Microscopy technology is a milestone technology in structural biology. RNA interference technology can specifically eliminate or turn off the expression of specific genes [11]. It has been widely used to explore gene function and the treatment of infectious diseases and malignant tumors [2, 7]. In 2006, Andrew Fahr and Craig C. Mello won the Nobel Prize in Physiology and Medicine for their contributions to the study of RNAi mechanisms [22].

Fig. 4. Keyword emergence map of articles published in Nature magazine from 2001 to 2020 (Photo credit: Original)

Fig. 5. Keyword emergence map of articles published in Science magazine from 2001 to 2020 (Photo credit: Original)

According to the mutation map of Nature and Science mutation terminology, Nature's mutation term "cell cycle" means that the mutation duration is up to 8 years, and Science's mutation term "direct observation" means that the mutation duration is up to 9 years; In terms of time, Nature's mutation term "double-strand breaks" (2005–2011), "embryonic stem cells" (2008–2014), and "tumour growth" (2014–2020) lasted for 7 years. Science mutations The term "RNA interference" (2002–2009) and "human cells" (2013–2020) last for 8 years; Nature's mutation terms, such as "tumour growth", "mouse model", "cancer cells", "cryo-electron microscopy structure", "cryo-electron microscopy", "degrees celsius", "cryo-em structure", "tumour Cells", "cell type", and science mutation terms, such as "human cells", "cryo-electron microscopy", "many-boby system", "cell type", "single cells", "major challenge", "square centimeter", "perovskite solar cells", "conformational change", "ambient condition", "cryo-electron microscopy structure", "mouse model", "structural basis", "physical property", the mutation time lasted until 2021. This shows that the research field represented by these terms is the frontier field of scientific research today. Specific analysis of the meaning of these mutation terms, we can see that the research methods of cryo-electron microscopy and the research of tumor direction are the frontier research areas of Nature. The use of cryo-electron microscopy research methods, human cells, single cells, conformational changes, structural basis, and perovskite-type solar cells are the frontier research areas that Science magazine focuses on.

4 Conclusions

Science and technology are the primary productive forces of social progress and economic development, and have a profound impact on the country's politics, economy, culture, and society. The competition between countries is the competition of comprehensive national strength, and the core is the competition of scientific and technological strength, science and technology have become an important standard to measure a country's international competitiveness. Grasping the frontiers of science and technology and seizing the commanding heights of science and technology is the key to the success of innovation entities in the competition. Studying and judging future technological development trends and identifying frontier areas of science and technology will provide scientific basis and important support for innovative entities to make strategic deployments. Nature and Science are internationally recognized top comprehensive journals, and the published articles represent the most cutting-edge and innovative research in this field. By conducting bibliometrics research on the published articles, we can understand the distribution of the world's top scientific and technological innovation institutions, the world's most cutting-edge research direction, and the world's hottest research field. Therefore, it has a very high reference value for the bibliometrics research of Nature and Science articles.

This study mainly uses Citespace and Vosviewer software, based on web of Science database platform, to conduct quantitative analysis and research on the literatures published in Nature and Science journals from 2001 to 2020. This study explores the number of articles published in these two internationally recognized top comprehensive journals in different countries and regions, research direction, characteristics of

institutional cooperation, characteristics of keyword co-occurrence, research hot spots and frontier trends. The results show that the world's major industrial countries are the main forces of global scientific and technological innovation. At the same time, China's scientific and technological innovation capability has risen rapidly in the last decade and become an important force in global scientific and technological innovation. The research of malignant tumor and artificial intelligence is the hotspot of current research. The mutation intensity of the mutation term in Nature is significantly higher than the mutation degree of Science. "Cryogenic electron microscopy" and "RNA interference" technology are the research frontiers that Nature and Science magazine pay attention to together. The results of cooperative research show that the aggregation effect is obvious by country and region; Eight of the top 10 high-producing organizations in the journals Nature and Science are from the United States, the other two are from France and Germany; Colleges and universities are the main force and birthplace of original innovation. The results of keyword co-cluster analysis show that, among the six keyword clusters, the other five topics are all related to life science, except the first topic is related to atmospheric environment research, indicating that the scientific and technological innovation activities in the field of life science are very active in the contemporary world.

References

1. Arkhipov D (1999) Scientometric analysis of Nature. J Scientometrics 46(1):51–72
2. Borkhardt A (2002) Blocking oncogenes in malignant cells by RNA interference—new hope for a highly specific cancer treatment? Cancer Cell 2(3):167–168
3. Braun T, Glänzel W, Schubert A (1989) National publication patterns and citation impact in the multidisciplinary journals Nature and Science. Scientometrics 17(1–2):11–14
4. Chen C (2004) Searching for intellectual turning points: Progressive knowledge domain visualization. Proc Natl Acad Sci 101(suppl 1):5303–5310
5. Chen C (2006) CiteSpace II: detecting and visualizing emerging trends and transient patterns in scientific literature. J Am Soc Inform Sci Technol 57(3):359–377
6. Chen C (2017) Science mapping: a systematic review of the literature. J Data Inf Sci 2(2):1–40
7. Cheng JC, Moore TB, Sakamoto KM (2003) RNA interference and human disease. Mol Genetics Metabolism 80(1–2):121–128
8. Cohen T, Widdows D, Schvaneveldt RW, Davies P, Rindflesch TC (2012) Discovering discovery patterns with predication-based semantic indexing. J Biomed Inform 45(6):1049–1065
9. Francis G, Tanzman J, Matthews WJ (2014) Excess success for psychology articles in the journal Science. PloS One 9(12):e114255
10. Gates AJ, Ke Q, Varol O, Barabási A-L (2019) Nature's reach: narrow work has broad impact. Nature Publishing Group
11. Hannon GJ (2002) RNA interference. Nature 418(6894):244–251
12. Hewish A, Bell SJ, Pilkington JD, Scott PF, Collins RA (2013) 74. Observation of a rapidly pulsating radio source. A source book in astronomy and astrophysics, 1900–1975, pp 498–504. Harvard University Press
13. Jardine JG et al (2016) HIV-1 broadly neutralizing antibody precursor B cells revealed by germline-targeting immunogen. Science 351(6280):1458–1463
14. Južnič P, Pečlin S, Žaucer M, Mandelj T, Pušnik M, Demšar F (2010) Scientometric indicators: peer-review, bibliometric methods and conflict of interests. Scientometrics 85(2):429–441
15. Kaneiwa K et al (1988) A comparison between the journals Nature and Science. Scientometrics 13(3–4):125–133

16. Liang L, Rousseau R (2009) Bibliometric characteristics of the journal Science: Pre-Koshland Koshland and post-Koshland period. Scientometrics 80(2):359–372
17. Lopez O et al (2001) Liposomes as protective agents of stratum corneum against octyl glucoside: a study based on high-resolution, low-temperature scanning electron microscopy. Micron 32(2):201–205
18. Milne JL, et al (2013). Cryo-electron microscopy–a primer for the non-microscopist. FEBS J 280(1):28–45
19. Monastersky R, Van Noorden R (2019) 150 years of nature an analysis of the archive. Nature 575(7781):22–23
20. Read ND, Jeffree CE (1991) Low-temperature scanning electron microscopy in biology. J Microsc 161(1):59–72
21. Rubinstein E, Dong G (1995) Random talk on American journal of science. Chin J Sci Tech Periodicals 6(03):53–54
22. Schwartz EI (2009) Potential application of RNAi for understanding and therapy of neurodegenerative diseases. Front Biosci 14:297–320
23. Shuangshuang G, Xueli L, Shile Z (2014) SCI source journal impact factor prediction and structure analysis method——take Nature magazine as an example. Chin J Sci Tech Periodicals 25(08):980–984
24. Taylor J (2011) Nature, a scientific journal for all researchers with a high impact factor. Oxford Univ Press, Great Clarendon ST, Oxford, OX2 6DP, England
25. Van den Besselaar P, Heimeriks G (2006) Mapping research topics using word-reference co-occurrences: a method and an exploratory case study. Scientometrics 68(3):377–393
26. Van Eck NJ, Waltman L (2010) Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics 84(2):523–538
27. Waaijer CJ (2013) Careers in science: policy issues according to Nature and Science editorials. Scientometrics 96(2):485–495
28. Waltman L, Van Eck NJ, Noyons EC (2010) A unified approach to mapping and clustering of bibliometric networks. J Informetrics 4(4):629–635
29. Wang J, Cai Y, Yang J, Zhao X (2021) Research trends and frontiers on source appointment of soil heavy metal: a scientometric review (2000–2020). Environ Sci Pollut Res 28(38):52764–52779. https://doi.org/10.1007/s11356-021-16151-z
30. Watson JD, Crick FH (1953) Molecular structure of nucleic acids: a structure for deoxyribose nucleic acid. Nature 171(4356):737–738
31. Wilmut I, Schnieke AE, McWhir J, Kind AJ, Campbell KH (1997) Viable offspring derived from fetal and adult mammalian cells. Nature 385(6619):810–813
32. Yan L, Xiufeng W (2002) Review of scientific journals and its implications. Sci Technol Rev 09:25–27
33. Yang C et al (2019) Intermediate bosonic metallic state in the superconductor-insulator transition. Science 366(6472):1505–1509
34. Zhang Y, Li C, Ji X, Yun C, Wang M, Luo X (2020) The knowledge domain and emerging trends in phytoremediation: a scientometric analysis with CiteSpace. Environ Sci Pollut Res 27(13):15515–15536. https://doi.org/10.1007/s11356-020-07646-2
35. Zhigang W (2018) Technological innovation and national core competitiveness. Sci Technol Ind China 06:16–19