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Historiography of Scientific Publishing across Cultures and Disciplines

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Abstract

Historiography is a vital perspective of our scientific literature that charts the evolution of scientific publishing, from its early origins to the present status. The key transformations including the shift from a limited self-published legacy to specialized and professional peer-reviewed journals, the impact of technological advancements, and the emergence of new profitable business models are learning points for the future course and couture. Science is pursued and persevered by real humans in social and cultural contexts and not in isolation of laboratories or clinics. Survival of the impartial pure scientific bent of mind and its translation into tangible works has not been easy through the turmoil of various forms of force majeure. The lack of gender parity and even its divergence in some ways was palpable in the discourse of scientific research. Despite that, when provided with a common platform with comparable impact factors and rates of publications, gender inequality seems to vanish and equivalence in academia is discernible. The roles of authors, publishers, and readers have also evolved chronologically, adapting to the influence of cultural and disciplinary factors through the ages. The challenges of predatory publishing, open access, plagiarism, and data capitalization are also growing alongside. Ultimately, understanding the historical context and persistence of the predecessors in the course of scientific publishing can enhance modern scientific research and communication.

Keywords
- scientific publication
- peer review
- scientist
- revolution
- open access
- digital publishing
- scholarly communication

Introduction

Scientific publishing in its present form is often perceived as a neutral, objective conduit for disseminating research. Yet, its history is a complex tapestry woven from threads of sociocultural, economic, and political influences. From the oral and manuscript traditions of antiquity to the print era and the contemporary digital age, the evolution of scientific communication has been a dynamic process shaped by diverse forces. Most of the scientific literature in olden times was restricted to self-published books, usually based on someone's lifetime experiences or the periodic letters written between like-

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minded intellectuals. They were guarded by the others for their secrecy and priority of the contained knowledge, and sometimes publicly shared in gatherings, often claiming authenticity and ownership over others.[1] From the handwritten scripts circulated among scholarly networks of the ancient world to the vast digital archives accessible at the fingertips of billions today, the methods of scientific publication have mirrored the broader transformations of society. At its core, scientific publishing is about communication—the sharing of ideas, discoveries, and methodologies. Yet, the forms, channels, and audiences for this communication have evolved dramatically over time. To understand the full impact of scientific publishing, it is important to explore its complex discourse across cultures and disciplines. By examining it in the historical context, we can gain valuable insights into the complex interplay between knowledge production, dissemination, and societal change. This interdisciplinary quest offers opportunities to learn from the multidimensional factors that have shaped the development of science, which can influence the future of scientific communication in an increasingly interconnected world.

Ancient Scientific Wisdom

Humankind began researching and communicating (results of their research) very early on during its existence. Few relics of the same can be found in old caves in the form of drawings, writings (in primitive local dialects), and seals. Our Indian legacy is replete with numerous methods, techniques, and other means of obtaining fruitful results from regional, scientific, cultural, and social experiments. Extensive literature on scientific wisdom exists, namely the Vedas, Vedangas, Puranas, Nyaya, Meemamsa, and Dharmashastra. The Vedas (Rigveda, Yajurveda, Atharvaveda, and Samaveda) are the most famous of all Sanskrit scriptures and are considered among the oldest in the world (perhaps more than 3,000 years old). They are the source of science, integral wisdom, culture, and tradition of a remarkable civilization (►**Fig. 1**). They are oral–aural compilations of cosmic knowledge survived from time immemorial. *Veda* means knowledge and is regarded as revealed scripture, self-evident, and self-authoritative. Rigveda is the oldest of these and comprises 10 books (mandalas). Its relevance is evident as it highlights the scientific bent of mind that Vedic thinkers had at that time. Their inquisitiveness about themselves, their ambient world, and their role here on this earth were remarkable. These texts, which subsequently came into existence, when penned by disciples and scientists, set the tone for future scientific publishing.

Tender Beginnings of Scientific Publishing: Pre-20th-Century Nuances

The originator of the scientific publications is the author. He or she could be a scientist, doctor, economist, or musician. The etymology of the word "author" in English can be traced to the 14th century from the Latin word *auctor*, meaning the creator, derived from the word *augere*, which means "to originate." The word "journal" of French origin (primarily meaning "day") has had a swaying etymological journey through the 13th to 17th centuries. Initially, it referred to the "book of church services" for use on a specific day of the year, later transiting with time to the book of daily transactions, daily notices, daily schedule of routes for travelers, daily record of public events, and finally becoming

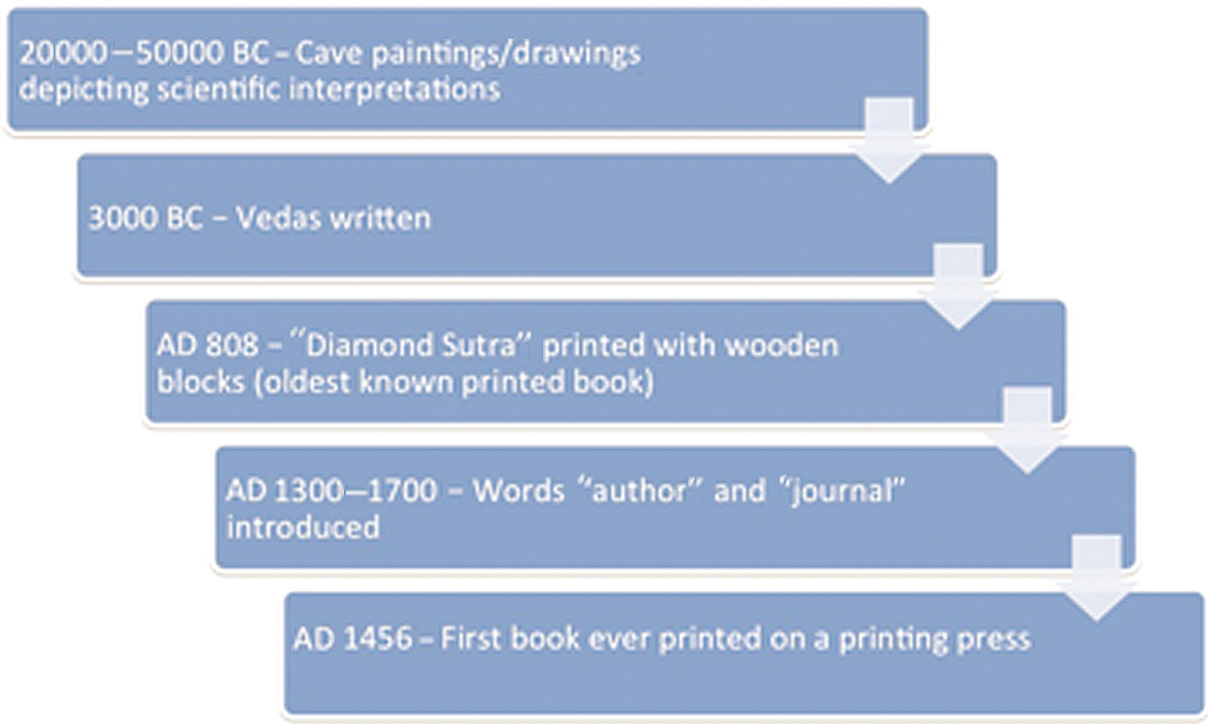

Fig. 1 Timelines showing the evolution of research publications during primitive times.

synonymous with the newspaper in the 18th century.[2] Similarly, the etymology of science comes from the Latin word *scientia*, meaning "knowledge." From its broader philosophical usage to a more specific and technical transition that was observed through the 17th and 18th centuries for this world, the word scientist was first used in the year 1834 for a person serving as an anonymous reviewer for a quarterly periodical. It was subsequently mentioned to be a person cultivating signs and scientific practices in general, thus replacing the older term of natural philosopher.[3]

Far from the current trends, scientific publishing in the olden times was neither a popular nor a remunerating practice even among the best minds of their times. Most of the great scientists, prior to the 20th century had few publications, with none or very few co-authors, and were even reluctant to publish their own names![4] The great Vesalius was charged with murder in 1564 for dissecting a nobleman with a beating heart as claimed by a witness! He was also sentenced to a long travel for pilgrimage to Jerusalem as a truncated punishment.[5] As a massive change from the inefficient and unreliable manual methods, significant milestone in Western printing can be dated to 1452, when Gutenberg developed the first movable typewriter in Europe that could produce speedy prints without mistakes.[6] Religious and cultural manuscripts for mass dissipation occupied the majority of work initially. Only after approximately 200 years, breaching the trend in the times of scientific deliberations being restricted to the closed-group intellectual exchanges, the first scientific journals were born in the year 1665. The French *Le Journal des Sçavans* (*Journal of the Experts*) and the English *Philosophical Transactions* were the pioneer publications of the same year (►**Fig. 2**).[7,8] The world's first radiology journal, *Archives of Clinical Skiagraphy*, emerged in the United Kingdom just 6 months after Wilhelm Roentgen's groundbreaking discovery of X-rays in 1895. This publication served as the foundational stepping stone for the later establishment of the *British Journal of Radiology*.[9] From those tender beginnings till the 20th century, there has been a swaggered increase in peer-reviewed scientific journals, doubling every 20 years with an average rate of approximately 3.46% per year.[10] Paradoxically, the methods of peer review in medical literature were described much before the surge of Western scientific publishing. Ishaq bin Ali Al-Rahawi (AD 854–931), a Syrian physician, was the first to describe the peer review process for the medical profession in his book *Ethics of the Physician* (*Adab al-Tabīb*).[11] The *Edinburgh Medical Journal* was the first peer-reviewed periodical since 1733, which influenced other contemporaries too. Interestingly, this rate of growth of new journals and published manuscripts was largely unaffected by wars and political changes unlike that of the 20th century encompassing the world wars and pandemics.

Droplet to Deluge: Course of Scientific Publishing in the 20th Century and Beyond

Peeling far away from the typical pre-19th-century singleton and sole authorship, the number of authors, both mean and maximum, per article, increased drastically, especially toward the latter half of the 20th century. Some of them were even hyper-authored, in which more than a hundred scholars contributed to the research.[1] There was a surge of conclusions derived from novel ideas and planned experiments, unlike the older research papers that largely consisted of merely observational data rather than truly intentionally and deliberately conducted and controlled experimental data. Up to 90% of the articles in the initial century of the earliest scholarly journal, *Philosophical Transactions*, pertained to the reports of various kinds of unusual earthquakes or births of variably anomalous fetuses, etc.[12] The more recent journals like the *Lancet* also had humble beginnings in 1823 by publishing the London Medical Teaching Hospital lectures for the benefit of students. It grew by leaps and bounds and went on to report concurrent and relevant landmark randomized controlled trials in the next centuries. Despite being just a Wakley family business initially and devoid of affiliation to any renowned scientific societies, *Lancet* might not have been the first journal in the history of scientific literature, but surely was the first to last (so long).[13]

A sea of change in the pattern of writing and communication also took place, gradually moving toward a mature and standardized structure of scientific writing. Although suggested in the initial decades of the 20th century, the "IMRaD" pattern of manuscript writing (consisting of Introduction, Methods, Results, and Discussion) came into widespread usage after World War II.[14] Vancouver Group and later, the International Committee of Medical Journal Editors (ICMJE), further led to the standardization of manuscript contents

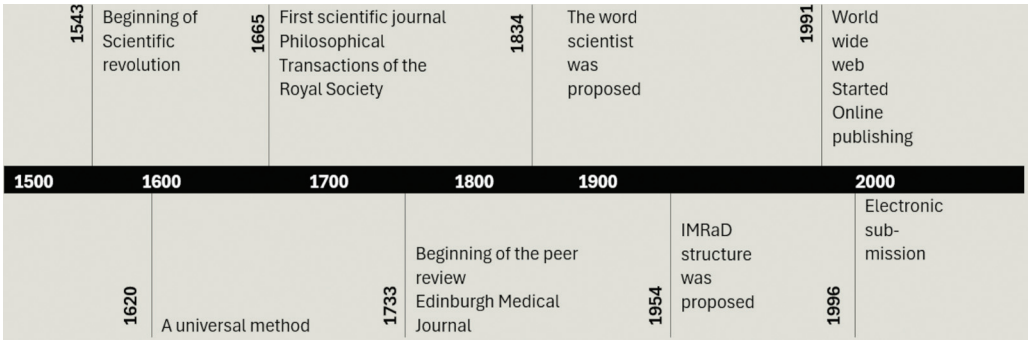

Fig. 2 Schematic diagram showing the timeline of important events in the history of contemporary scientific publishing.

and bibliography. Despite some criticism from a section of scholars, the "IMRaD" pattern persisted since it was convenient for the increasingly busy scientists to note down and submit their findings systematically. The year was 1959 when the commercial availability of the photocopier machine was a landmark for the peer review process, comparable to Gutenberg's movable typewriter for the journal printing legacy. There was a palpable flipping of the roles of peer reviewers and assistant editors from simply encouraging and eliciting good articles to fill the respective empty page spaces available in the journals to quality picking, faster and effective scholar review consultation, and rejection of suboptimal papers.[15]

Some interesting trends observed in the 20th century were an increased number of words per title (mean of 8.7 in 1970 vs. 11.83 in 2014), longer abstracts (mean words of 116.3 in 1970 vs. 179.8 in 2014), higher number of references per article, and increased number of self-citations.[16] The prolific Russian scientist, Yuri Struchkov, penned over 2,000 research papers during his lifetime (1926–1995). His exceptional productivity earned him an Ig Nobel Prize as he managed to publish an astonishing 948 articles between 1981 and 1990—an average of 1 paper every 3.9 days for a full decade. On the other side, Fredrick Sanger, the only double Nobel prize–winning British Biochemist with just about a hundred papers in his lifetime, was cited over 100,000 times, signifying the immense impact of his works.[17] Number of citations is considered a simplistic indicator of the academic influence that a research, author, journal subject, or even a country may carry. The most cited article ever was from the *Journal of Biological Chemistry*, garnering approximately 2,95,169 citations to date and it continues to be cited at least 2,000 times a year in the last 5 years![18] However, in general, about half of the published articles remain uncited for at least 5 years from their acceptance. That figure goes much lower with passing time, and it is estimated that approximately 10% of the published literature remains uncited.[19] It is observed that since the advent of open access (OA) journals, there has been a gradual decline in the citations and also resultant submission in established popular journals like *Lancet* and *Nature*, causing tectonic shifts in scientific communications.

The trend in scientific literature published on PubMed over the past two decades (2000–2020) reveals a striking disparity in growth rates across different paper types. While the overall number of published articles tripled, clinical trials saw a more modest twofold increase, suggesting a plateau in recent years. Conversely, systematic reviews and meta-analyses experienced exponential growth, increasing 19-fold during the same period.[2] Scientific publishing, once a non-commercial endeavor largely sustained by scientists' own resources, has dramatically transformed into a highly lucrative industry. Dominated by for-profit and not-for-profit organizations primarily based in Western Europe and North America, the industry generated over $26.5 billion in global revenue in 2020. Scientific journals have become the core products of this industry, characterized by unique business models that are flourishing well.[20] Robert Maxwell's Pergamon Press, taken over later by Elsevier, joined the league of "big-five publishers of the world" consisting of Elsevier, Springer Nature, John Wiley, Sage, and Taylor & Francis, which continues to grow with significant profits.[21] These publishing houses are relevant even today with their optimal dynamic adaptation to the digital formal communique as well as widespread social media footprint.

Technological Advancements and Their Impact

The Transition from Print to Digital Publishing

"Project Gutenberg" proposed by Michael Hart in the year 1971 was the first digitization project that resulted in the digitization of the Declaration of Independence and the creation of the first free online digital library.[22] Digital books and journals evolved swiftly with advancements in the World Wide Web by the end of the 20th century. Digital formal scientific communications could beat the traditional prints in multiple ways including rapid dissemination, trouble-free storage, rapid correction and updating, and collaborative and interactive distribution along with searchable text.[23] *Encyclopedia Britannica*, the famous book of knowledge with the legacy of 244 years of publications, discontinued physical prints after the last 32 volumes in the year 2010. The Google Book Search project of 2004 was among the first of its kind with an endeavor to create a worldwide virtual library, preserving the legacy of printed knowledge digitally.[24] With the wide and increasing access to digital content, the model of scientific publishing has taken a transit mode from print only to either print-on-demand, digital-only, or print-and-digital models. With the proliferation of digital literature search engines like Google Scholar, Scopus, and Web of Science, citation and data metrics have become seamless and transparent.[25]

The Rise of Open Access and Its Implications

OA is a great breakthrough in the history of scientific publishing, truly rendering knowledge output of the world's scientific community freely accessible.[26] In the first decade of the 21st century, there was about an 18% surge in the number of OA journals, with a 30% increase in published articles.[27] The governments, educational institutes, and scientific societies were also promoting the idea of no-cost knowledge for the benefit of all. However, the OA movement, while intended to democratize knowledge, has inadvertently fostered the proliferation of numerous low-quality, digital-only journals. These predatory publishers, characterized by their lack of rigorous editorial processes and questionable ethical standards, have experienced explosive growth. Emerging from a handful of entities in 2010, their numbers swelled to over 1,100 by late 2016. Employing deceptive tactics such as misleading journal titles, fabricated editorial boards, and inflated impact factors, these publishers prioritize profit over academic rigor. They circumvent essential quality control measures like peer review and ethical guidelines established by organizations like the ICMJE and the

Committee on Publication Ethics (COPE), resulting in the annual publication of hundreds of thousands of substandard articles through approximately 8,000 predatory journals. By preying on the desire for quick and easy publication, predatory publishers undermine the credibility of the entire scholarly ecosystem and erode public trust in research.[28]

Sci-Hub, a shadow library founded by Alexandra Elbakyan in 2011, has emerged as a highly controversial yet influential player in the realm of scientific publishing. By providing free access to millions of research papers behind paywalls, Sci-Hub has challenged the traditional business model of scholarly communication and ignited a fervent debate about OA to knowledge. Proponents contend that scientific research is a public good funded primarily by taxpayers and therefore its dissemination should not be restricted by exorbitant paywalls.[29] The negative influence of the shadow libraries on researchers' citation practices is increasingly evident by revealing some unexpected findings about their impact on the Open Access Citation Advantage (OACA).[30,31]

The Newer Challenges to Scientific Publication in Its True Essence

Data capitalism in scientific publishing, in its simplistic terms, is the commoditization of research data and their valuable inferences. Publishers, often commercial entities, collect vast amounts of data from authors, readers, and subscribers. These data include article downloads, citation metrics, user behavior, and even the content of research papers themselves. These data are then analyzed, packaged, and sold to various stakeholders, including pharmaceutical companies, market research firms, and investment banks. There is a growing recognition that the pursuit of profit should not compromise the public good of scientific research.[32] The rise of a scientific publishing lobby has created a complex ecosystem where publication, power, and patronage are intertwined. This system has led to increased inequities, such as authorship disparities, and transformed scientific publishing into a means of career advancement. The enormous issue of plagiarism of text and ideas in scientific writing has also become a major cause of retraction/rejection of manuscripts from revered journals. However, the problems of the editorial team are alleviated partly by the robust plagiarism checkers like iThenticate from Turnitin. The motive for such deliberate malpractices originates from the overemphasis on publishing in high-impact journals as a metric for hiring, promotion, and funding decisions, which has distorted the core values of science. This pressure-cooker environment has fostered questionable research practices and compromised the integrity of scientific findings. Ultimately, the original motivations for publishing have been overshadowed by the relentless pursuit of publication metrics.[33]

Apples and Oranges: Impact of Cultural and Disciplinary Differences

Science is pursued and persevered by real humans in social and cultural contexts and not in isolation of laboratories or clinics. Recognition of the social and cultural cues affecting the scientific judgment, as well as the plausibility of the publication processes, many a time explains incommensurability in various scientific publications.[34] The *New England Journal of Medicine* (NEJM), one of the established medical journals in the world showed astute negligence to the scientific research ongoing at the time under the vehemently racist and antisemitic Nazi rule. Initially, the NEJM was unperturbed, mostly remaining silent or at times even appreciating the forced sterilization policy of Nazi medicine or supporting the narrative of their biased state health insurance policy.[35] Predominantly after the Helsinki Declaration of 1964 that established ethical principles of human experimentation, so many articles in the NEJM retrospectively noted the deceitful mass extermination methods used by the Nazi doctors and scientists.[36]

The development of scientific literature has been far from a linear path, mostly riddled with multiple variations and paradoxes in various disciplines of science. In the American Ornithology aspects, "The Birds of the Republic of Colombia (TBRC)," the works of Rodolphe Meyer de Schauensee (1948–1952) in the journal *Caldasia* brought a sea of changes in Colombia. It established Colombia as the place of the world's greatest bird biodiversity and invigorated many to marvel at the publishing methods of the country with a hitherto unknown international footprint of scientific research at that time. During the period of the TBRC series printing, the Colombian economy was battered by surging inflation along with newer policy changes post-Second World War. *Caldasia*, used to publish 13.8 articles on an average in two to four issues per year from 1940 to 1948. It came down to a single article in a single issue for 4 years during the TBRC period! Despite the financial, operational, and editorial crunches during this period, the journal was kept alive, by the editorial office. Paradoxically, those precious single annual issues gained great popularity among ornithology enthusiasts and yielded the maximum multifactorial dividends in the long run.[37]

From the gender-based perspective, on average, male scientists publish more articles than their female counterparts, with a 27% productivity gap. However, this disparity varies across different performance levels. While the gap is evident among high-achieving scientists (the top 20% male scientists have 37% more papers than their female counterparts), it disappears for mid-level researchers and is even reversed for those at the lower end of productivity. Despite an overall increase in female representation among the authors from 12% in 1955 to 35% in 2005, women remain underrepresented, especially in fields like Mathematics, Physics, and Computer Science, while achieving parity in others like Psychology. Geographical disparities also exist, with countries like Russia (~50%) showing greater gender equality in science in comparison to Germany (~28%).[38] However, it is proven that for a given number of publications with comparable impact factors and rates of publications, gender inequality almost vanishes with equivalent growth in academia.

COVID-19 Pandemic: Fuel to the Explosion of Publications

The unprecedented pandemic-related surge in morbidity and mortality compounded by the social distancing norms in the era of well-disseminated internet availability triggered a frenzy of scientific papers concerning COVID-19 from various perspectives. Worldwide authors' tectonic and exponential trend shifts of publication in the history of publishing toward the single most interesting topic of COVID-19 were palpable from across the globe. It was facilitated by various systematic changes like fast-track peer reviews, waving off the article publication charges (APC), and free access to the published articles in all journals.[39] Swift modifications, errata generation, and even apologetic retraction of the published articles in renowned journals were also not uncommon.[40,41] Except for China, the number of COVID-19-related indexed articles was largely proportional to the respective national mortality in the top 10 worst-hit nations. The initial surge of preventive methods and containment strategies as prime focuses of contemporary literature was swiftly subdued by the subsequent publications concerning the trials of newer therapies, diagnoses of newer subspecialized entities, and hitherto undiagnosed COVID-associated afflictions. The year 2020 saw ever-surging online submissions of articles, resulting in special issues and dedicated sections concerning the coronavirus in almost all types of medical journals.[42]

Increasing online communications transformed the traditional publishing culture into various forms of digital couture, to an extent, forever thereafter. Another interesting trend that developed was the increasing decoupling of the immediate information dissemination and the detailed peer evaluation of the research data. The practice of sharing the research findings as preprints online, separate from the time-consuming formal peer review of the journals, gained widespread acceptance. The COVID-19 pandemic underscored the critical importance of rapid access to scientific information. To facilitate this, numerous nonprofit preprint servers, similar to arXiv, have emerged in various fields. Even major commercial publishers presently continue to offer preprint services, allowing authors to share their work publicly before final publication.[43] The postpandemic publication stats are comparable to the contemporary Indian stock market growth with daily onboarding of fresh and younger people. The amount of data analyzed and manuscripts prepared by today's greenhorn researchers using modern artificial intelligence (AI) tools in a short time may be tantamount to years of hard work and persistence by the team of scholarly scientists in olden times. Taking the cues from historical events, it is a moral liability to be involved in the practice of just, ethical, and unbiased research avoiding the low-hanging fruits like plagiarism, data fabrication, or falling for predatory journals.

Popular Scientific Databases: NLM and PubMed

There existed many public and private repositories of scientific abstracts across few languages and geographical boundaries. However, the landscape of research and publishing was transformed with the introduction of PubMed, a large public repository of journal abstracts (https://www.ncbi.nlm.nih.gov/). PubMed is a free database supporting the search and retrieval of biomedical literature with the ultimate aim of improving global health care. It was developed and maintained by National Center for Biotechnology Information (NCBI), a subsidiary of the U.S. National Library of Medicine (NLM) at the National Institutes of Health. It comprises over 37 million citations and abstracts of biomedical literature indexed in NLM's MEDLINE database, as well as from other life science journals and online books. First introduced in 1971, online access to the MEDLINE database was primarily through institutional facilities like college libraries. However, it was partially released for free for home and office-based MEDLINE searching in January 1996. Subsequently, in June 1997, it was completely opened for free to the entire public. PubMed usage has increased exponentially with a jump of searches from approximately 2 million/mo during its initial years to approximately 3.5 million/d currently, indicating its popularity among the researchers. The team of PubMed ensures accuracy of the database by following stringent protocols for journal and article selection, maintenance of robust hardware and software, and systematic indexing process with multivariable user-friendly search options.[44]

Artificial Intelligence and Scientific Research

The recent introduction of AI tools to scientific research has impacted publication in a unique way. While its ability to handle large datasets, performing complex computations, revealing new research questions, and improving communication of research findings has positively transformed the research scenario, it has added certain challenges like misuse and threats to the integrity of publishing and paper writing.

Language modes like large language models help researchers whose first language is not English. They help in paper writing and translation eventually adding to the quality of research papers.[45] AI helps in simplifying data analysis taking care of large data management and interpretation. It helps in complex computations, which used to take significant time, energy, and resources previously and many a time abandoned for want of expertise. Learning new paradigms from data has become possible, facilitating future advances.

It still remains a double-edged sword. Among its few negatives, false inference due to haphazard application of AI techniques, perpetuation of bias and discrimination by AI tools, and misinformation and plagiarism pose particular threats to research quality. Moreover, AI involves use of powerful computing hardware, which requires robust funding, which is not always possible.

For AI to be an effective tool for research and paper writing, researchers require access to powerful computing resources, reduced knowledge barrier, and strict adherence to ethical AI practices.

Conclusion

Scientific journals are the primary channels for disseminating research and knowledge globally. By examining the

historical journey of publishing marked by significant achievements and challenges, we can appreciate it as a dynamic and continually evolving system. Understanding the sacrifices and immense difficulties faced by earlier researchers instills in young scientists a strong ethical foundation for unbiased and evidence-based publishing. Simultaneously, it enthuses all of us to swagger ahead with technological advancements while carefully avoiding the mistakes of the past.

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