

# Literature Review

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## Todo list

## 1 Enhancing Reproducibility in Scientific Research Through Open Science and Decentralized Technologies

### 1.1 The Imperative of Reproducibility in Scientific Research Science

Science as a systematic and empirical pursuit of knowledge, fundamentally relies on the ability of researchers to verify and build upon the findings of their predecessors and peers. At the core of this process lies the concept of reproducibility, which encompasses both the capacity for others to obtain consistent results using the same data and methods, and the ability to achieve similar findings when new data is collected through the same experimental design ?? . A significant concern has emerged within the scientific community regarding the difficulty of reproducing the results of numerous published scientific studies across a wide spectrum of disciplines. This phenomenon, frequently referred to as the "reproducibility crisis", has shaken the foundations of scientific inquiry, leading to a growing lack of trust in research findings ?. The concerning high rates of non-reproducible research, with studies suggesting an average failure rate of 50%, indicate a systemic issue that extends beyond isolated cases of flawed methodology or misconduct ?. To provide context on the financial impact of low reproducibility rates in the life sciences, estimated annual losses in the United States alone exceed \$28 billion, primarily attributed to research that fails to meet reproducibility standards ?.

### 1.2 Challenges to Scientific Integrity

The consequences of the reproducibility crisis extends beyond the academia to affect public trust in science, slow down the translation of research into practical applications, and potentially lead to the misallocation of substantial resources and the implementation of misinformed policies based on unreliable findings.

The inability to reproduce preclinical research, for example, can significantly delay the development of therapies that are life saving, increase the pressure on already strained research budgets, and drive up the costs associated with drug development. The societal impacts are also significant, with misdirected effort, funding, and policies potentially being implemented based on research that cannot be validated ?.

Several interconnected factors contribute to this crisis, spanning issues within the publication system to the prevalence of questionable research practices and the inherent complexities encountered in certain scientific disciplines. Journals often exhibit a publication bias, preferentially publishing novel and positive results while overlooking negative findings or replication studies ?. This creates a skewed representation of the scientific landscape and can lead to the neglect of important information about what does not work ?. Furthermore, researchers may engage in questionable research practices, such as p-hacking (manipulating data to achieve statistical significance) and HARKing (hypothesizing after results are known), which can distort results and make replication exceedingly challenging. Inadequate statistical methods, including the use of suboptimal analyses, can also lead to erroneous conclusions, further hindering the replication process. A significant contributing factor is the lack of data sharing among researchers; when data and methods are not openly accessible, the ability of others to verify and replicate the work is severely limited ?.

The intense pressure to publish, often described by the expression "publish or perish," can incentivize researchers to prioritize the quantity of publications over their quality, potentially leading to rushed and less rigorous research. Incentive structures within universities may inadvertently reward the mere act of publication in prestigious journals, sometimes at the expense of methodological rigor and the pursuit of accurate and reproducible findings. This competitive environment can implicitly or explicitly encourage the use of questionable research practices to achieve publication, such as selectively reporting parts of datasets or trying different analytical approaches until the desired outcome is obtained ?.

The reproducibility crisis in science also reveals a strong connection between data management practices and the ability to replicate experimental results. Transparent and accessible data are essential for verifying findings and ensuring their reliability across disciplines. Insufficient metadata, unavailability of raw data, and incomplete methodological reporting are major contributors to irreproducibility. Without proper documentation and sharing protocols, researchers face significant barriers in reusing or validating published results ?.

### **1.3 A Paradigm Shift Towards Transparency and Collaboration**

In response to concerns about the reproducibility and reliability of scientific production, a movement emerged advocating for a fundamental transformation in how knowledge is generated and disseminated, emphasizing transparency, accessibility, and collaboration within the scientific community and with the broader

public. Although the ideals of openness and sharing have long been embedded in scientific practice, the Open Science movement gained momentum with the advent of the internet and the more interactive capabilities made available by the Web 2.0 ?.

## 1.4 Open Science Principles as Solutions to the Reproducibility Crisis

The Open Science practices are designed to confront reproducibility issues by promoting greater transparency, accessibility, and collaboration in scientific research. Among these practices, five core principles stand out: Open Data, Open Materials, Open Access, Preregistration, and Open Analysis. These principles address systemic issues that undermine the credibility and reliability of scientific outputs and seek to realign research practices with the foundational values of openness and verifiability ?.

Table 1: The Five Principles of Open Science, according to ?

Principle	Description
Open Data	Making research data freely available for others to inspect, reuse, and build upon, supporting transparency and reproducibility.
Open Analysis	Sharing code, workflows, and analysis scripts used in the study to allow others to verify and replicate the results.
Open Materials	Providing full access to the materials, tools, and instruments used in the research, such as surveys, interventions, protocols or software.
Preregistration	Publicly registering study designs, hypotheses, and analysis plans before data collection to prevent selective reporting and increase research integrity.
Open Access	Ensuring that research outputs, including publications, are freely accessible to all, removing barriers imposed by paywalls, subscriptions or restrictive licensing.

A central element of this framework is the commitment to Open Data, which calls for unrestricted access to raw research data and associated metadata. This principle directly addresses the lack of transparency that often impedes reproducibility by ensuring that the empirical foundation of research is available for validation, reinterpretation, and reuse. Open Data repositories serve a critical role in this ecosystem by preserving datasets in standardized formats, maintaining provenance metadata, and enabling persistent access. Provenance information about the origin, context, and transformations applied to the data is particularly important, as it supports reproducibility by providing a traceable record of how datasets were collected, processed, and interpreted. Without these metadata standards and traceability mechanisms, shared data risk becoming uninterpretable or misleading when repurposed ??.

Linked to Open Data is the principle of Open Materials, which involves making the research components such as experimental protocols, instructions

and interventions. Open Materials ensure that researchers seeking to replicate a study or extend its methodology have access to the same inputs and tools used in the original work. Depositing these materials in domain-specific repositories and documenting them with clear metadata and provenance records enhances both transparency and usability ?.

Open Access complements these practices by addressing the dissemination of research outputs. It entails making peer-reviewed publications freely available without subscription or payment barriers. Open Access expands the reach and impact of scientific knowledge, enabling researchers from under-resourced institutions and disciplines to participate in scholarly discourse and replication efforts. In conjunction with preprints—versions of manuscripts shared prior to peer review—Open Access accelerates the circulation of ideas and allows the broader community to scrutinize findings earlier in the research lifecycle. This early-stage visibility invites broader feedback and can help identify methodological flaws or inconsistencies that might otherwise go unnoticed until post-publication ?.

To strengthen methodological transparency, Open Science also promotes Preregistration, which involves submitting a time-stamped outline of the research questions, hypotheses, and study design prior to data analysis. The adoption of preregistration discourages questionable research practices such as HARKing (Hypothesizing After the Results are Known) and p-hacking, thereby increasing transparency and reducing publication bias. This enhances the credibility of findings throughout the experimental process. Preregistered reports can be submitted to dedicated registries, assigned unique identifiers, and tracked by provenance systems that ensure the integrity and traceability of the research workflow ?.

Finally, Open Analysis entails sharing the code and computational workflows used in data processing and statistical inference. By making analysis pipelines available, researchers allow others to reproduce exact outputs from shared data, supporting both validation and reuse. Integration with containerization tools, version control systems, and computational notebooks strengthens this principle, enabling complete provenance tracking of computational environments and decisions ?.

Finally, Open Analysis involves the disclosure of code and computational workflows employed in data processing and statistical inference. By making analysis pipelines accessible, researchers enable others to reproduce the exact outputs from shared datasets, thereby facilitating both validation and reuse. The adoption of containerization tools, version control systems, and computational notebooks further reinforces this principle by enabling comprehensive provenance tracking of computational environments and analytical decisions ??.

Together, the five principles of Open Science—Open Data, Open Materials, Open Analysis, Preregistration, and Open Access form a cohesive approach to improving the reliability and transparency of scientific research. By promoting the use of open repositories, standardized metadata, and accessible workflows, these practices reshape how knowledge is produced and shared, fostering a more trustworthy and collaborative research environment.

## **1.5 Current Initiatives and Standards for Enhancing Research Reproducibility**

## **1.6 Key Initiatives in Open Science and Research Data Management**

The growing emphasis on transparency, reproducibility, and collaboration in scientific research has led to the emergence of several influential initiatives that support the implementation of Open Science and effective Research Data Management (RDM). These initiatives provide frameworks, tools, and community-driven guidelines that help researchers and institutions manage data more responsibly, ensuring that research outputs are not only preserved but also accessible and reusable. By fostering interoperability, encouraging FAIR (Findable, Accessible, Interoperable, and Reusable) data practices, and promoting a culture of openness, these efforts contribute to a more trustworthy and efficient research ecosystem. This section discusses a selection of leading initiatives spanning international collaborations, policy frameworks, and infrastructural developments that collectively shape the evolving landscape of Open Science and RDM.

## **1.7 Key Initiatives in Research Data Management and Open Science**

### **1.8 Leveraging European Research Data (LEARN)**

The LEARN Toolkit (Leveraging European Research Data) was developed to assist research institutions in implementing effective Research Data Management (RDM) policies and practices. Grounded in the recommendations of the LERU (League of European Research Universities) Roadmap for Research Data, the Toolkit offers guidance on institutional policy development, advocacy, training, infrastructure, and best practices. It emphasizes the strategic role of data management planning and encourages institutions to embed RDM into the research lifecycle. By providing a series of model policies, case studies, and checklists, LEARN promotes a culture of data stewardship aligned with the principles of FAIR data (Findable, Accessible, Interoperable, and Reusable), contributing to the broader objectives of Open Science ?.

### **1.9 FAIR Guiding Principles**

The FAIR Guiding Principles represents a cornerstone of responsible data stewardship in the context of Open Science. These principles aim to improve the infrastructure supporting the reuse of scholarly data. By encouraging data producers to make their outputs Findable, Accessible, Interoperable, and Reusable, FAIR fosters machine-readability, long-term preservation, and seamless data integration across platforms and disciplines. Although not inherently open, FAIR complements Open Science by providing the technical and semantic standards

necessary for data sharing and reuse. Adoption of FAIR principles by research funders, repositories, and institutions has significantly influenced data policies across scientific communities and reinforced efforts toward more transparent and collaborative research practices ?.

### **1.10 GO FAIR**

The GO FAIR initiative builds on the momentum of the FAIR principles, functioning as a bottom-up, stakeholder-driven movement to implement FAIR data stewardship globally. It encourages the development of implementation networks—collaborative groups that share expertise and develop domain-specific solutions for achieving FAIR data practices. GO FAIR’s focus extends to governance, education, and infrastructure, aiming to create a distributed ecosystem that facilitates the reuse of scientific data. By promoting interoperability standards and cultural change across the scientific community, GO FAIR advances Open Science by ensuring that data outputs can be seamlessly discovered, accessed, and reused across institutional and national boundaries ?.

### **1.11 Research Data Alliance (RDA)**

The Research Data Alliance (RDA) is a global community-driven initiative that brings together data practitioners, technologists, and policymakers to build the social and technical infrastructure necessary for open data sharing across disciplines. Founded in 2013, RDA operates through working groups and interest groups that develop recommendations, standards, and best practices for data interoperability and stewardship. The RDA fosters international cooperation and bridges disciplinary gaps by aligning data governance, metadata standards, and infrastructure development. Its outputs support the implementation of Open Science by ensuring that research data is not only preserved but also rendered useful and actionable across diverse research contexts ?.

### **1.12 Committee on Data of the International Science Council(CODATA)**

CODATA is an international organization committed to advancing data science and improving the quality and accessibility of research data. It plays a vital role in the global Open Science ecosystem by supporting the development of data policies, fostering international collaboration, and providing strategic guidance on data governance. CODATA actively contributes to the advancement of the FAIR principles and supports initiatives that aim to make research data a reusable, sustainable, and equitable public good. Through its coordination efforts and engagement with global stakeholders, CODATA helps shape the infrastructures and norms that underpin responsible data sharing and Open Science ?.

### **1.13 Open Access Infrastructure for Research in Europe (OpenAIRE)**

OpenAIRE represents a pan-European initiative designed to support the open dissemination and reuse of research outputs. Originating as a response to the European Commission’s Open Access policies, OpenAIRE has developed into a robust infrastructure that aggregates metadata and full-text content from a wide array of data providers, including institutional repositories, data archives, and scholarly journals. By facilitating interlinking between publications, datasets, software, and project information, OpenAIRE enhances the discoverability and interoperability of research products across disciplines. Its suite of services, such as the OpenAIRE Graph and Research Community Dashboards, provides tools for compliance monitoring, impact assessment, and reproducibility tracking. Furthermore, OpenAIRE actively contributes to policy development and technical alignment in the global Open Science ecosystem, advocating for standardized metadata schemas and persistent identifiers. Through its alignment with FAIR principles and support for the European Open Science Cloud (EOSC), OpenAIRE plays a foundational role in shaping a transparent, interconnected, and researcher-centric data landscape ?.

### **1.14 DataCite**

DataCite is a global non-profit organization that plays a foundational role in the research data ecosystem by providing persistent identifiers—most notably Digital Object Identifiers (DOIs)—for datasets and other research outputs. Founded to support data citation practices, DataCite promotes the discoverability, accessibility, and reuse of research data by ensuring that data can be persistently linked to scholarly publications and contributors. It collaborates with data centers, publishers, and repositories to establish metadata standards that facilitate interoperability across infrastructures. Through services such as DOI registration, metadata management, and citation tracking, DataCite actively contributes to the implementation of the FAIR principles and strengthens the overall architecture of Open Science and Research Data Management worldwide ?.

### **1.15 Nelson Memo - Office of Science and Technology Policy (OSTP)**

In 2022, the White House Office of Science and Technology Policy (OSTP) issued a directive known as the “Nelson Memo,” which requires that all federally funded research publications and associated data be made immediately and freely available to the public by December 31, 2025. This policy marks a pivotal shift in U.S. open access strategy by eliminating embargo periods and strengthening mandates for data transparency. Building on previous open science policies, the Nelson Memo seeks to ensure equitable access to publicly funded knowledge, drive reproducibility, and accelerate scientific progress through a national

commitment to openness and accountability ?.

Table 2: Comparison of Open Science Related Initiatives

Initiative	Coverage	Key Outputs	Contribution to Open Science
LEARN	Institutional; Europe (globally applicable)	RDM policy toolkit, model policies, case studies	Strengthens institutional capacity for implementing FAIR and Open Data policies
FAIR Guiding Principles	European Union	FAIR assessment tools, training materials, recommendations	Embeds FAIR principles into research workflows and infrastructures
GO FAIR	Global	FAIRification framework, implementation networks, training modules	Operationalizes FAIR principles through community-driven practices
EOSC (European Open Science Cloud)	Pan-European Infrastructure	EOSC Portal, service registry, metadata standards	Provides federated infrastructure to enable Open Science practices across disciplines
RDA (Research Data Alliance)	Global	Working group outputs, interoperability guidelines, standards	Enhances technical and social infrastructure for global data sharing
CODATA	Global (UNESCO)	Policy frameworks, capacity-building initiatives, data science standards	Supports Open Science through coordination of global data policy and governance
OpenAIRE	European Union	Research Graph, repository integration tools, metadata guidelines	Connects RDM and Open Access via aggregated infrastructure and metadata interoperability
DataCite	Global	DOI registration service, metadata schema, discovery APIs, DataCite Commons	Enables FAIR data by ensuring traceability, citation, and persistent access in open research
OSTP Nelson Memo	United States / Federal Policy	Mandate immediate public access to federally funded research outputs	Shapes U.S. policy landscape for Open Access and data sharing by 2026

## Decentralized Applications in Support of Open Science and Reproducibility

The limitations of traditional research data management systems have sparked growing interest in alternative models. Decentralized technologies, particularly blockchain, have gained increasing recognition for their ability to enhance transparency, accountability, and trust across various domains, including scientific research. Their potential to address long-standing inefficiencies and structural shortcomings within the research ecosystem has attracted significant attention from the academic community.

Blockchain has evolved into a broader paradigm of distributed ledger technology, collectively maintained by a network of nodes. Through immutability and consensus-based validation, it ensures the integrity of recorded data. These foundational features offer a technological infrastructure for verifying the authenticity, provenance, and persistence of digital records, features that align closely with Open Science objectives and the FAIR principles (Findable, Accessible, Interoperable, and Reusable). In an era of data-intensive research and multi-stakeholder collaboration, such assurances are critical for enabling reproducibility, facilitating the auditability of research processes, and ensuring reliable attribution of intellectual contributions.



Decentralized solutions introduce a novel approach to scientific data governance. This paradigm shift directly supports key principles of Open Science such as openness, inclusivity, reproducibility, and collaboration by embedding accountability and traceability into the technical fabric of research infrastructures.

In this context, decentralized applications function as strategic enablers of both cultural and procedural transformation in science. They offer pathways to reconfigure incentive structures, reduce access barriers, and reinforce the reproducibility and credibility of scientific outputs. The remainder of this section explores the current state of such applications, their underlying architectures, and the roles they play in advancing Open Science and addressing reproducibility challenges.

II. Overview of the NFAIS Conference on Blockchain for Scholarly Publishing (2018) The NFAIS Conference on Blockchain for Scholarly Publishing, held in May 2018, served as an early platform for stakeholders within the scholarly publishing community to convene and explore the emerging initiatives stemming from the increasing global acceptance of blockchain technology.<sup>1</sup> The timing of this conference indicates that 2018 was a significant year for the scholarly publishing community to begin earnest consideration of the implications of blockchain technology. This early focus suggests a proactive stance by the community to comprehend and potentially leverage a nascent technology. A primary emphasis of the conference was on blockchain's potential to transform researcher workflows across the entire spectrum, from the initial stages of data collection through the processes of peer review and ultimately to the dissemination of published work.<sup>1</sup> The broad scope of these discussions, encompassing the complete researcher lifecycle, points to an initial understanding of blockchain as a potentially transformative technology with far-reaching applications within academia. This holistic perspective indicates an early recognition of blockchain's capacity to extend beyond specific applications and influence the entire research ecosystem. Discussions at the conference also centered on blockchain's inherent ability to provide structured, decentralized, and immutably secure approaches to managing scholarly information.<sup>1</sup> The repeated emphasis on decentralization and immutability underscores the fundamental reasons why blockchain is considered a promising technology for addressing trust and security concerns in academic communication. These features directly tackle issues such as data tampering and the critical need for reliable, verifiable records within the scholarly domain. Furthermore, the conference explored the application of blockchain technology to specific areas within scholarly publishing, including the validation of peer review activities, the protection of intellectual property rights, and the effective tracking of research outputs.<sup>1</sup> The focus on peer review, intellectual property protection, and output tracking reveals the initial areas where blockchain was perceived as offering tangible solutions to existing challenges in scholarly publishing. These are critical aspects of the publishing process where trust, security, and efficient management are of paramount importance. Several presentations at the NFAIS conference showcased specific platforms and initiatives that were beginning to leverage blockchain technology for scholarly

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communication, including ARTiFACTS and Po-et.<sup>1</sup> The emergence of platforms like ARTiFACTS and Po-et demonstrates the proactive efforts within the community to transition from theoretical discussions to the development of concrete blockchain-based solutions for scholarly publishing. These initiatives represent early attempts to translate the potential of blockchain into practical tools for researchers and publishers. The overall atmosphere of the conference was characterized by a blend of enthusiasm and skepticism regarding the ultimate transformative potential of blockchain technology within scholarly publishing.<sup>1</sup> The presence of both passionate proponents and cautious skeptics at the conference indicates a thoughtful and critical initial assessment of blockchain technology within the scholarly publishing community. This balance is essential for a realistic understanding of the technology's potential and limitations. Some speakers articulated a vision of a truly open scholarly commons facilitated by decentralized networks and blockchain infrastructure.<sup>1</sup> The vision of a "scholarly commons" suggests a potential paradigm shift enabled by blockchain, moving towards more open and collaborative models of knowledge creation and dissemination. Decentralized networks could empower researchers and potentially reduce the control of traditional gatekeepers in publishing. Conversely, other speakers emphasized the importance of considering existing technologies and established norms within the scholarly publishing ecosystem.<sup>1</sup> The call to build upon existing technologies and social norms indicates a recognition that the adoption of blockchain in scholarly publishing should be an evolutionary rather than a revolutionary process. Integrating blockchain with established practices could facilitate a smoother transition and increase the likelihood of successful adoption.

III. In-depth Analysis of Scholarly Articles on Blockchain in Publishing

III.A. "An overview of the NFAIS conference: Blockchain for scholarly publishing" (10.3233/ISU-180015) Published in Information Services and Use, Volume 38, Issue 3, in 2018 <sup>1</sup>, this article, likely authored by Bonnie Lawlor <sup>2</sup>, provides a summary of the 2018 NFAIS conference focusing on blockchain in scholarly publishing. The publication of this overview in a peer-reviewed journal shortly after the conference underscores the importance and timeliness of the topic for the information services community. This rapid dissemination of conference highlights indicates a strong interest and perceived relevance of blockchain for scholarly publishing within the field. The main topics discussed revolve around the potential of blockchain to impact researcher workflows, its applications in peer review, intellectual property protection, and research output tracking.<sup>1</sup> The key takeaway from the conference, as highlighted in the article, is that blockchain promises a more structured, decentralized, and secure approach to scholarly communication, with various initiatives actively exploring its use across the entire research lifecycle.<sup>1</sup> Specific examples and use cases mentioned include ARTiFACTS for creating immutable records of research, Po-et for managing digital assets, Knowbella Tech for facilitating decentralized research grants, and the concept of decentralized citation ledgers.<sup>1</sup> The article points to the opportunity for blockchain to open up horizontal discovery and create greater trust and transparency between publishers, while also noting the need for broader awareness and adoption of the technology.<sup>1</sup> The overall perspective presented

is that blockchain holds significant long-term potential to transform scholarly publishing, although short-term expectations might be somewhat inflated.<sup>1</sup> In summary, "An overview of the NFAIS conference: Blockchain for scholarly publishing" (10.3233/ISU-180015) summarizes the key discussions at the NFAIS conference on blockchain for scholarly publishing. The article highlights the potential of blockchain to revolutionize researcher workflows, enhance data security, and foster trust within the academic community. Various initiatives and use cases, such as ARTiFACTS for research provenance and decentralized grant management, were presented, alongside discussions on the opportunities and challenges associated with the broader adoption of this technology in scholarly publishing. The overall perspective suggests that while blockchain holds considerable promise for the future of academic communication, its widespread implementation requires further development and understanding. III.B. 10.3233/ISU-180016 ("Blockchain and scholarly publishing could be best friends") Authored by Mads Holmen from Bibblio and published in Information Services Use, Volume 38, Issue 3, in 2018<sup>17</sup>, this article explores the potential benefits of blockchain for decentralization, unbundling, and empowering content creators within scholarly publishing. The title itself suggests a strong belief in the synergistic potential between blockchain technology and the needs of the scholarly publishing ecosystem. The use of the phrase "best friends" implies a mutually beneficial relationship where blockchain can provide solutions to key challenges in the field. The article discusses the dominance of major internet platforms in content discovery and the imperative need for better tools and enhanced recognition for researchers.<sup>17</sup> A key takeaway is that blockchain offers a significant opportunity to redistribute power in content discovery and foster greater trust and transparency among publishers, emphasizing that focusing on the needs of creators is crucial for building successful platforms.<sup>17</sup> Specific examples mentioned include token-based systems like Steem and Basic Attention Token (BAT) for directly rewarding creators, as well as LBRY, a platform aiming to connect content creators and audiences directly.<sup>17</sup> The article also addresses the challenges in content accessibility and monetization, highlighting the opportunity to establish a more efficient economic ecosystem for scholarly content, which might necessitate a fundamental shift in traditional revenue models.<sup>17</sup> The overall perspective is that blockchain has the potential to create a more efficient ecosystem for scholarly content by reducing costs associated with the delivery chain and improving the overall user experience, although this transformation might require the adoption of new revenue streams.<sup>17</sup> In summary, the article "Blockchain and scholarly publishing could be best friends" (10.3233/ISU-180016) argues that blockchain technology can address the dominance of major internet platforms in content discovery and empower researchers. It discusses the potential for decentralization and unbundling in scholarly publishing, emphasizing the importance of focusing on the needs of content creators. The article highlights examples of token-based systems and platforms that aim to reward creators directly and suggests that blockchain can lead to a more efficient economic ecosystem for scholarly content by improving access and potentially requiring new revenue models. III.C. 10.3233/ISU-190053 ("Making the unconventional

conventional: How blockchain contributes to reshaping scholarly communications”) Authored by David Kochalko, co-founder of ARTiFACTS, and published in *Information Services Use*, Volume 39, Number 3, in 2019 19, this article explores how blockchain technology can advance Eugene Garfield’s long-standing vision of providing comprehensive recognition for all forms of research contributions. The title suggests a vision where blockchain-based approaches will eventually become the norm in scholarly communication, indicating a long-term perspective on the technology’s impact. The article delves into the potential of blockchain for various applications, including publishing platforms, open science initiatives, recognition and attribution services, and the development of underlying infrastructure within the research and academic fields.<sup>19</sup> A key takeaway is that blockchain can empower researchers to receive due credit for their entire body of creative work, encompassing even pre-published research outputs, and platforms like ARTiFACTS are specifically designed to secure the provenance and ensure accurate attribution of these contributions.<sup>19</sup> The article highlights the opportunity to enhance researchers’ careers by making pre-published research more accessible and formally recognized.<sup>19</sup> The overall perspective presented is that blockchain technology, particularly through platforms like ARTiFACTS, has the potential to fully realize Garfield’s vision of comprehensive researcher recognition, ultimately driving progress within the scientific community.<sup>19</sup> In summary, ”Making the unconventional conventional: How blockchain contributes to reshaping scholarly communications” (10.3233/ISU-190053) explores how blockchain technology can help achieve Eugene Garfield’s vision of providing researchers with recognition for all their creative works. The article discusses various applications of blockchain in scholarly communication, with a particular focus on the ARTiFACTS platform. ARTiFACTS utilizes blockchain to enable researchers to establish the provenance of their work, protect their intellectual property, and receive attribution for all types of research output, including pre-published findings, thereby aiming to advance researchers’ careers and support the validation of scientific findings. III.D. 10.3233/ISU-180003 (”The blockchain and its potential for science and academic publishing”) This article, authored by Joris van Rossum from Digital Science and published in *Information Services Use*, Volume 38, Issues 1-2, in 2018 6, examines the potential of blockchain technology to address several persistent challenges within science and academic publishing. The article’s publication in the same year as the NFAIS conference and the other *Information Services Use* articles indicates a concentrated period of exploration and discussion around blockchain in this journal. This suggests that the journal served as an early forum for thought leaders to share their initial insights and perspectives on the topic. The main topics discussed include the potential of blockchain to improve peer review processes, enhance research reproducibility, and refine research metrics. Additionally, the article explores the possibility of utilizing cryptocurrencies for science funding and rewards, implementing digital rights management for scholarly content, and establishing decentralized data storage solutions.<sup>6</sup> Key takeaways include the potential of blockchain to facilitate micropayments for accessing content and rewarding reviewers, to improve the management of digital rights, to create

decentralized repositories for research data, and to enhance the reliability and sophistication of research metrics.<sup>6</sup> The article specifically mentions the concept of a "bitcoin for science" as a potential model for funding and rewarding scientific activities, alongside existing blockchain-based initiatives such as Scienceroot and Pluto.<sup>6</sup> While acknowledging the significant potential advantages, the author also cautions about the potential resistance to adoption due to the legacy of existing technologies, systems, organizations, and culture within the scientific community.<sup>6</sup> The overall perspective is that blockchain has the potential to significantly benefit scholarly communication by addressing critical issues like reproducibility and peer review, although widespread adoption may face considerable challenges.<sup>6</sup> In summary, "The blockchain and its potential for science and academic publishing" (10.3233/ISU-180003) explores how blockchain technology could tackle current problems in science and academic publishing, such as issues with peer review, the reproducibility crisis, and limitations in research metrics. The article discusses potential applications like using cryptocurrencies for science funding and rewards, implementing digital rights management for scholarly content, and creating decentralized storage for research data. While acknowledging the significant potential benefits, the author also cautions about the resistance that might arise due to existing technologies and cultural norms within the scientific community. III.E. 10.37394/23207.2022.19.51 ("A Blockchain Cloud Computing Middleware for Academic Manuscript Submission") Published in WSEAS Transactions on Business and Economics, Volume 19, in 2022 23, this article presents a more recent contribution to the field, focusing on a specific application of blockchain in manuscript submission. The focus on cloud computing middleware suggests an understanding of the need to integrate blockchain technology with existing technological infrastructure in academia. Rather than proposing a complete overhaul, this approach aims to enhance current systems by incorporating blockchain's specific strengths. The main topics addressed are the improvement of academic manuscript submission and peer review processes through the implementation of a blockchain-based cloud framework, with the aims of enhancing anonymity, increasing decentralization, and ultimately reducing publication bias.<sup>24</sup> A key takeaway is that a cloud middleware architecture leveraging blockchain technology can effectively enhance the anonymity between authors and reviewers, and the proposed system is designed to optimize the overall peer-review process.<sup>24</sup> The article provides specific examples and use cases, including a proposed four-tier middleware architecture and a detailed algorithm for reviewer selection, with a planned implementation utilizing open-source tools such as Java Spring and the Ethereum blockchain.<sup>24</sup> The authors highlight the opportunity to create a privacy-focused and decentralized system for manuscript submission, while also acknowledging the potential challenges associated with real-world implementation and ensuring scalability.<sup>24</sup> The overall perspective is that the proposed blockchain-based cloud framework demonstrates promising initial results for improving the efficiency and anonymity inherent in academic manuscript submission and peer review.<sup>24</sup> In summary, "A Blockchain Cloud Computing Middleware for Academic Manuscript Submission" (10.37394/23207.2022.19.51) presents a novel

cloud framework that utilizes blockchain technology to improve the academic manuscript submission and peer-review process. The proposed system aims to enhance anonymity between authors and reviewers, thereby reducing publication bias. The paper details a four-tier middleware architecture and an algorithm for reviewer selection, with a planned implementation using open-source tools like Java Spring and the Ethereum blockchain. The results of simulated data tests suggest the potential of this approach to create a more decentralized and privacy-focused submission system. III.F. 10.3389/fbloc.2019.00016 ("A Review on Blockchain Technology and Blockchain Projects Fostering Open Science") Published in *Frontiers in Blockchain*, Volume 2, in 2019 29, this article provides a focused review on the application of blockchain technology to the domain of open science. Published in a journal dedicated to blockchain research, this article provides a focused review on its application to open science. The categorization of 60 blockchain projects offers a valuable snapshot of the diverse ways in which the technology was being explored to support open science initiatives around 2019. This systematic overview helps to identify key trends and areas of active development within the intersection of blockchain and open science. The main topics covered include the potential of blockchain to foster open science principles, a comparative analysis of blockchain characteristics against the requirements of an open science ecosystem, and a comprehensive review of existing blockchain projects specifically designed to advance open science.<sup>29</sup> Key takeaways from the review highlight the strong alignment between blockchain's core features, such as decentralization, immutability, and transparency, and the fundamental tenets of open science. The review also notes the numerous projects exploring the use of blockchain for enhancing research reproducibility, facilitating resource sharing among researchers, and ensuring the protection of intellectual property within open science frameworks.<sup>29</sup> The article identifies several challenges and opportunities associated with this intersection, including the inherent risks and the need for robust validation of smart contracts, the current lack of standardization and established frameworks for blockchain implementation in science, the complexities of designing sustainable incentive systems for open science initiatives, and the potential for blockchain to improve the reliability and scope of scientific metrics.<sup>29</sup> The overall perspective presented is that blockchain technology holds significant potential to provide a reliable and appropriate infrastructure for supporting open science endeavors. However, the authors emphasize that successfully realizing this potential hinges on effectively addressing the identified challenges and achieving widespread acceptance from both the scientific community and relevant stakeholders.<sup>29</sup> In summary, "A Review on Blockchain Technology and Blockchain Projects Fostering Open Science" (10.3389/fbloc.2019.00016) examines the potential of blockchain technology to support and advance the goals of open science. The paper compares the characteristics of blockchain with the requirements of an open science ecosystem and provides a comprehensive review of 60 existing blockchain-based projects aimed at fostering open science. These projects are categorized by their focus, such as improving reproducibility, facilitating resource sharing, and ensuring transparent evidence. The authors conclude that while blockchain offers a

promising infrastructure for open science, its successful implementation depends on addressing challenges related to standardization, incentives, and community adoption. III.G. 10.1007/978-3-030-71593-9<sub>2</sub>("Ants – Review : A Privacy – Oriented Protocol for Incentivized Open Peer Reviews on Ethereum") Published as a chapter in Euro-Par 2020 : Parallel Processing Workshops in 20219, this work addresses the persistent issue of lacking a dequate incentive-oriented protocol" highlights a key concern within the academic community regarding the potential exposure of fider based peer reviews solutions among researchers. The authors propose a novel blockchain – based incentive system built on the Ethereum platform, introducing Ants – Review, a protocol designed for an anonymous based system can effectively reward scientists for their time and intellectual effort in conducting peer reviews. The Review protocol allows authors to offer bounties, denominated in a native token called ANT S, for peer reviews that Review protocol, outlining its various modules, including those for access control, ensuring privacy through the Ants Review presents a promising blockchain – based solution to address the limitations of the current peer reviews system Review : A Privacy – Oriented Protocol for Incentivized Open Peer Reviews on Ethereum" (10.1007/978-3-030-71593-9<sub>2</sub>) addresses the issue of lacking incentives for scientists to conduct peer reviews. The paper proposes Review, a privacy – oriented protocol based on smart contracts on the Ethereum platform. This protocol allows authors Review has the potential to improve the efficiency, quality, and fairness of the scientific publication process by incentive Promises and Challenges") Published in the Journal of Open Innovation : Technology, Market, and Complexity Promises and Challenges" (10.3390/joitmc6040117) examines the potential benefits and obstacles associated with Potential and prospects") Published in Learned Publishing, Volume 34, Number 4, in 202118, this article specifies a proof method for tracking and verifying crucial journal performance metrics, such as citation counts, usage statistics. Potential and prospects" (10.1002/leap.1408) explores the potential of blockchain technology to improve the evaluation 01-2022-0010("Blockchain solutions for scientific paper peer review : a systematic mapping of the literature") review process for scientific papers. Published in a journal focusing on data technologies, this article provides a comparison of an unrewarded peer review process. The primary goal of the study is to analyze the characteristics of the current blockchain based peer review process of scientific papers. The study analyzes the characteristics of 26 identified articles, revealing trends and based peer – reviews solutions. III.K. 10.1007/978-3-030-77417-2<sub>16</sub>("Fostering Open Data Using Blockchain Technology and off-chain, proposing innovative solutions such as "moving smart contracts" to maintain the privacy of research data. 3-030-77417-2<sub>16</sub>) explores how blockchain technology can be used to promote the sharing of research data as open data. Fungible Token (NFT) in the academia and open access publishing environment : Consideration toward science friendly scenarios") Published in The Journal of Electronic Publishing, Volume 25, Number 2, in 202244, this article Fungible Tokens (NFTs) within the academic and open access publishing landscape. The Journal of Electronic Publishing friendly scenarios" highlight the need to tailor the application of emerging technologies like NFTs to the specific needs through library – or scholarly – led university presses and repositories, via a central articles submission platform for friendly implementation, including the importance of cost – free generation and transfer of NFTs to authors, thus making power regarding their NFTs, the need for low complexity and minimal additional workload for researchers. Fungible Token (NFT) in the academia and open access publishing environment : Consideration toward science friendly scenarios" (10.3998/jep.2574) explores the potential of Non – Fungible Tokens (NFTs) to create a value friendly scenarios for their integration, such as through library – led university presses, central submission platform, free generation, researcher control, and high interoperability for NFTs to be effectively adopted in the academic community. 021-01776-2("OpenLab : A web application for running and sharing online experiments") Published in Behavior based solutions also aim to support. The paper highlights OpenLab as a server – side application that significantly simplifies the complex process of deploying online studies built with lab.js, a browser – based experiment builder. 47 Accessible at https://open-lab.online, the platform offers a fast, secure, and transparent environment for researchers to upload their studies. friendly and open – source solution that not only reduces the technical complexities associated with conducting online studies. A web application for running and sharing online experiments" (10.3758/s13428-





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