Méndez, E., Sánchez-Núñez, P. (2023). Navigating the Future and Overcoming Challenges to Unlock Open Science. In: González-Esteban, E., Feenstra, R.A., Camarinha-Matos, L.M. (eds) Ethics and Responsible Research and Innovation in Practice. Lecture Notes in Computer Science, vol 13875. Springer, Cham.

DOI: https://doi.org/10.1007/978-3-031-33177-0_13

Navigating the Future and Overcoming Challenges to Unlock Open Science

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Abstract. Open Science (OS) has been rapidly evolving in recent years, but there is still work to be done to return Science to researchers and citizens who pay for it. Technological advancements have enabled Open Science to transform the way scientifi research is conducted, facilitating collaboration and innovation among researchers. As a result, OS is expected to play an increasingly important role in scientifi research and innovation in the years to come, driving discoveries and advancements in various fields However, OS also poses challenges, including the potential for bias and discrimination in research. This chapter explores the challenges that need to be addressed to fully implement OS globally, outlining the barriers that need to be overcome and describing the complexity of the changes that come with this new research approach. Additionally, the chapter discusses the impact of Artificia Intelligence on addressing these challenges, while also creating new ones.

Keywords: Open Science · Science Policy · Scholarly Communication · Research Evaluation · Intellectual Property · Artificia Intelligence · Responsible Research and Innovation (RRI)

1 Introduction: Open Science in RRI

Responsible Research and Innovation (RRI) implies a philosophical and far-reaching ethical approach, which assesses society's expectations regarding research and innovation, to foster equity and sustainability in research and innovation. As other chapters of this book explain, RRI includes Open Access (OA) as an extra/added/common element, along with ethical issues, gender equality, citizen participation or public engagement, scientifi education, and governance of the scientifi and innovative process. Stahl define RRI as a "higher-level responsibility or meta-responsibility that aims to shape, maintain, develop, coordinate and align existing and novel research and innovation-related processes, actors, and responsibilities to ensure desirable and acceptable research outcomes" [1]. RRI's ethical principles and meta-responsibility include open access to knowledge, but also entail all the processes and challenges of Open Science (OS). The RRI concept has been used to describe a new way of governing research and the relationships between the agents involved, called the quadruple helix when we talk about innovation: academia,

E. González-Esteban et al. (Eds.): The ETHNA System Project, LNCS 13875, pp. 203–223, 2023.
https://doi.org/10.1007/978-3-031-33177-0_13

industry, government and civil society [2]. These four players are also the key stakeholders in making Open Science a reality. The orchestration of these four stakeholders and how their relationship and engagement in OS is articulated is key to overcoming OS's current challenges.

Research and Innovation are becoming more and more digital, complex, data-driven and so reliant on powerful computing capabilities, which has given rise to e-Science and scientifi computing. This leads to a better understanding of complex scientifi problems, faster progress in scientifi discovery, and more accurate and reliable scientifi information. Meanwhile, digital technologies, particularly the World-Wide Web, which facilitates "distributed collaborative research behaviour" [3] and the possibility of immediately, openly and massively communicating knowledge through the network, lead us to think about the promise of the transformation of science and the opening of research processes.

Helped along by these trends, Open Science has been gaining significan relevance in the past ten years, and it is expected to play a crucial role in shaping the future of scientifi research and innovation [3]. Despite that, we financ and carry out research in the same way as in the last century and publish and assess it as we began doing several centuries ago. Institutions, researchers, and founders are hostages to an anachronistic, absurd and ineffective scientifi communication model based exclusively on 'the scientifi paper' as an end in itself. This 'paper-centric' model often leads to a simplistic conception of Open Science as 'Open Access to scientifi publications', just as it simplifie the quality of research to a high Journal Impact Factor (JIF). However, the last SWAFS Program report [4] includes OS rather than Open Access as a fundamental element of RRI, highlighting the importance of the fuller meaning of Open Science.

There are different systematic reviews around the definitio of Open Science [5, 6], and a plethora of terms to characterise or explain its essence: a movement, a trend, a paradigm, a construct, or an attitude [7], in the scientifi research ecosystem. All the definition emphasise transparency, collaboration, and access to data, publications, methodologies, software and any other research outcome. OS aims to promote scientifi knowledge that is accessible to all, rather than being restricted to a select few. It has become a key element of Responsible Research and Innovation that promotes scientifi advance by enabling researchers to collaborate, co-create and build upon each other's work, fostering innovation by making the latest information and developments easily accessible, increasing public trust in science by promoting reproducibility through more transparent scientifi data and methods, and supporting interdisciplinary research by encouraging collaboration between different fields All this conceptualization of Open Science is right, but our favourite approach is to explain Open Science as giving Science back to the researchers that do it and to the citizens that pay for it. Figure 1 represents the particular view of Eva Méndez of OS's key components. Responsible Research and Innovation is the ethical and philosophical foundation that allows us to believe in Open Science. But the roots, which should cement the OS system, are research infrastructures, scientifi integrity and a new research evaluation system that can incentivise Open Science's practices.

Open Science (OS) is an achievable goal due to technical and policy advances. But if the research cycle cannot be shared, data cannot be reused, citizens are not involved

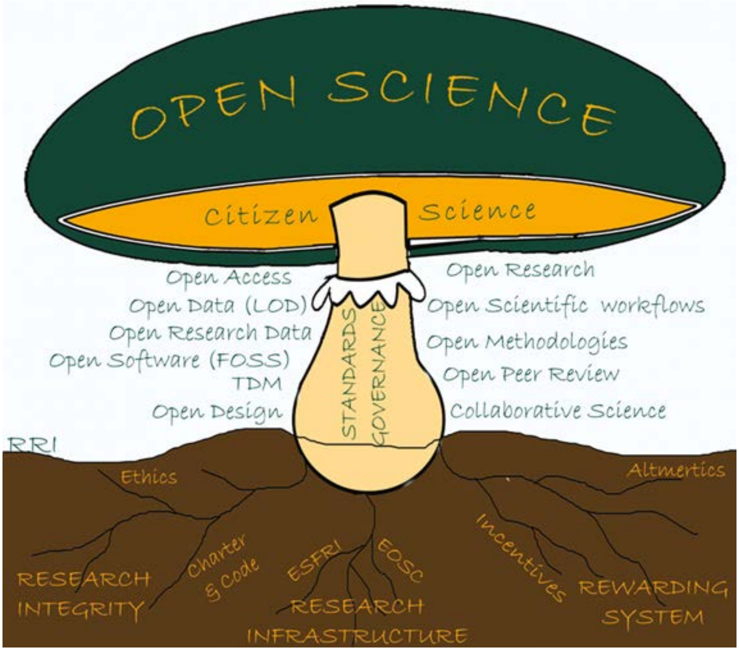

Fig. 1. Open Science Mushroom done by Judit Eva's Fazekas-Paragh (OpenAire NOAD (https://www.openaire.eu/blogs/hungary-on-the-move-1)) based on Eva Méndez's Open Science Mushroom [7].

and researchers cannot be assessed by their whole contribution to the system and OS practices, and the goals of OS will remain aspirations beyond the practical reach of many. Since we started to speak about OS as the new paradigm to make better, more efficien and transparent science, we constantly talk about 'drivers and barriers' [8], claiming to pass to action[1], but always pointing out at a lot of challenges [10–13].

This chapter shares the personal views of the authors on their meta-research for Open Science, based on their involvement in different groups and fora (e.g., OSPP[2], RDA[3], CoARA[4], YERUN Open Scienge WG[5], etc.) to evolve OS and make it a reality. The chapter offers a perspective on the current status of Open Science in the light of

[1] This was the sprit of the "Amsterdam Call For Action" in 2016 under the Dutch presidency. Source: https://www.openaccess.nl/sites/www.openaccess.nl/files/documenten/amstedam-call-for-action-on-open-science.pdf and also the work of the OSPP (Open Science Policy Platform) during the second mandate where it was define the PCIs concept: Practical Commitments for Implementation of Open Science[9].

[2] https://openscience.eu/open-science-policy-platform-final-repor

[3] https://www.rd-alliance.org

[4] Https://coara.eu

[5] https://yerun.eu/work/open-science

European policies and initiatives[6], UNESCO Recommendation[7], and the urgent changes needed to make Open Science the default approach. Those key changes are: the way we communicate Science; the way we assess research, researchers, and research performing organisations (RPOs); and the way we give credit in a new legal framework that protects research results, without leaving anybody behind. It will not be easy, but by addressing these challenges, the scientifi community should work together to create a more stimulating, transparent, accessible, fair, and equitable research ecosystem. Finally, we discuss the opportunity and challenge of Artificia Intelligence (AI) for Open Science implementation and the Responsible Research and Innovation ecosystem.

2 Framing up the 'Right to Science' and a Global Science Commons

Open Science (OS) is based on the principle that scientifi knowledge should be freely available to everyone, without restrictions [6]. This means that scientifi research should be conducted openly and transparently, with results being made publicly available through open-access publications and open-data platforms. Also, OS is based on the belief that it can promote greater collaboration, innovation, and scientifi progress, and can help to address global challenges such as poverty, inequality, and environmental degradation.

The OS movement, in the "democratic school" approach, emphasises that access to knowledge is a human right, so the social return on public investments in science (accountability) is the guarantee of this universal right [14]. The *Universal Declaration of Human Rights*[8] (1948, art. 27) established the fundamental right to science and culture. It is also recognized in other international declarations underlining the importance of science in the promotion of development and ensuring that individuals can "enjoy the benefit of scientifi progress and its applications" (*International Covenant on Economic, Social and Cultural Rights*[9] 1966, art. 15). However, it is often treated as a privilege. The International Covenant also recognizes the "freedom of the researcher" as an indispensable value, as well as cooperation in science[10]. Even though OS is a newer term, its values and principles are more than 50 years old. The essence of science is openness and collaboration, understanding it from the Mertonian perspective of knowledge as a 'common' or 'public good' defended among others by Hess and Ostrom [12, 15–17]. Geiger and Jütte have furthermore underlined the importance of "a right to research" substantiated in the European fundamental rights instruments (freedom of expression, freedom of arts and sciences and right to education) and defend a new definitio of a 'right to research' to remove copyright barriers in favour of research [18].

6 https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/open-science_en

7 https://en.unesco.org/science-sustainable-future/open-science/recommendation

8 https://www.un.org/en/about-us/universal-declaration-of-human-rights

9 https://www.ohchr.org/en/instruments-mechanisms/instruments/international-covenant-economic-social-and-cultural-rights

10 *Ibid.*

The United Nations has been supporting the discussion on a Global Science Commons since 2019 to discuss the key role of OS in the achievement of the UN 2030 Agenda, outlining a Science Commons as the framework organised around principles, universal values and the architecture of open research, and based in OS as a key accelerator of the Sustainable Development Goals[11]. In 2021, at the UN's meeting on Open Science, the "right to science[12]" was highlighted, and this year (2023), the meeting is focused on the idea of a *Global Open Science Commons for the Sustainable Development Goals,* based on three main topics: equity in open scholarship, reforming scientifi publishing, and strengthening the science-policy-society interface[13].

The discussion is centred around the key principle that researchers have the freedom to perform research, and that citizens have the right to access research outputs. The universal 'right to science', the 'right to research' and the principles of OS are closely linked, as they aim to promote greater access to scientifi knowledge and to ensure that the benefit of scientifi progress are shared by everyone.

UNESCO has played a key role in promoting the principles of OS and advocating for greater access to scientifi knowledge and information. The *UNESCO Recommendation on Science and Scientifi Researchers* [19] was adopted by the UNESCO General Conference in 2017. This firs recommendation does not speak about "Open Science" directly (it refers to open access, data, educational resources, software, etc.), but it sets out several principles and guidelines for promoting science and scientifi research that will ground the very recommendation of Open Science [20], including the importance of freedom of scientifi expression and inquiry, the promotion of ethical and responsible scientifi practices, and the need to ensure that the benefit of scientifi advances are shared fairly and equitably. Since the adoption of the UNESCO recommendation on science and scientifi research, there has been significan growth and development in the fiel of OS, with new initiatives, and practices emerging to support open and collaborative scientifi research (e.g. Hong Kong Principles[14], CoARA[15]).

The *Recommendation on Open Science* [20] was endorsed by the 193 members of the UN in November 2021. It provides a framework for promoting OS principles, including transparency, collaboration, and access to scientifi information. The recommendation aims to promote the democratisation of science, reduce barriers to access and participation, and ensure that scientifi knowledge is used to benefi all societies (Fig. 2).

This recommendation aims to provide a/the ultimate "vital tool" to improve the availability and quality of both scientifi outcomes and scientifi processes to bridge the gaps in science, technology, and innovation among different countries, in order to fulfi the human right of access to science. It offers governments, research institutions, and the scientifi community a set of precepts and principles for promoting and implementing OS. It recognizes the importance of OS for advancing scientifi knowledge, improving the quality of research, and enhancing the impact of science on society. The

[11] https://research.un.org/ld.php?content_id=51390330 (November 2019).

[12] https://www.un.org/sites/un2.un.org/files/open_science_outcome_document_ .3b.pdf (November 2021).

[13] https://www.un.org/en/library/OS23 (February 2023).

[14] https://www.wcrif.org/hong-kong-principles

[15] Https://coara.eu

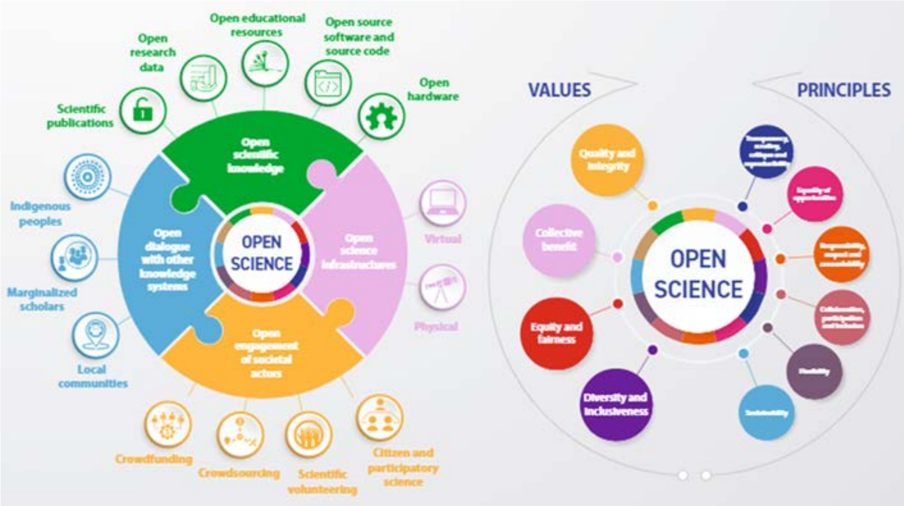

Fig. 2. Understanding Open Science (UNESCO Open Science Toolkit[16]).

recommendation also acknowledges the challenges posed by the rapid pace of technological change, and it calls for the development of international norms and standards to ensure that OS practices are consistently applied across different regions and scientifi disciplines [21].

UNESCO is "the legitimate global organisation enabled to build a coherent vision of open science and a shared set of overarching principles and shared values[17]", but "it is the response of working scientists, their institutions, and funders that will determine whether a new mode of Open Science is achieved as the 'new normal' and whether it realises the hopes of its proponents" [22]. The UNESCO document is not 'yet another declaration', it has developed an implementation plan with working groups and a steering committee[18], as well as a toolkit with guides to put the recommendations into practice[19]. The toolkit can benefi institutions in understanding Open Science, developing policies, funding OS, building capacity or bolstering OS infrastructures for all. The Open Scholarship Initiative (OSI), working in partnership with UNESCO, published a comprehensive roadmap for Open Science in light of the Recommendation, calling for a collective future for OS and Open Research. However, the future of Open Science is in the hands of individual researchers and the institutions underpinning their work, while the target of UNESCO recommendations is the member countries, which have different economic situations and different limitations in their funding, practices and procedures.

16 https://unesdoc.unesco.org/ark:/48223/pf0000383323

17 https://council.science/current/news/the-questionnaire-unesco-open-science-recommendation/

18 https://www.unesco.org/en/open-science/implementation

19 https://www.unesco.org/en/open-science/toolkit

3 Global Challenges for Open Science: Rocky Pathways Ahead

Open Science is a tremendously diverse and interconnected space. “Reforming it will not be as simple as claiming that open is X, the solution is Y, and the path to the future can be enforced by a unilaterally-developed mandate” [23]. Despite its potential benefits the future of OS is surrounded by big challenges, real changes and new frameworks [10], as well as the engagement of many stakeholders.

From the very beginning, the European Commission (EC) started to defin the elements of OS as 8 key challenges: four related to research outcomes (FAIR data, the European Open Science Cloud (EOSC)), next-generation metrics, and new scholarly communication mechanisms); and four challenges related to research stakeholders (evaluation of researchers’ careers, skills, and training in OS, new research integrity, and citizen science)[20]. The term ‘challenges’, like “barriers and drivers”, has always been used in the spirit of putting OS to work.

Several authors started to think about the future of Open Science and to point out at the challenges, realities, and current limitations [15, 27] even for publishers [28]. Pownall et al. [13] envision some key trends and developments for the future of OS, noting:

- Technological advancements make it easier for researchers to share and access data and software**.** The widespread adoption of cloud computing, for example, has made it possible for researchers to store, process, and analyse massive amounts of data from various sources. This, in turn, has facilitated collaboration between researchers, as they can now share data, publications, etc. and conduct ‘real-time research’ [28]. These developments are expected to make it easier for researchers to access and use data, as well as to collaborate on software development in different field [29], but also in cross-disciplinary research.
- Artificia intelligence (AI) is seen as a particularly powerful tool for scientifi research [30]. These technologies have the potential to revolutionise the way scientifi research is conducted, by allowing researchers to process and analyse vast amounts of data more efficientl . For example, AI can be used to analyse complex biological data, such as genomic data, and identify new drug targets for diseases. But AI also deals with ethical issues, as pointed out by ETHNA project [31]. AI entails new developments to analyse the impact of OS [32] better and faster (Cf. Section 4 below.).
- Open Science is also expected to play a critical role in addressing societal challenges such as climate change, healthcare, and poverty, among others.
- Traditionally, scientifi research has been highly fragmented, with researchers in different field often working in isolation. However, Open Science has the potential to break down these barriers and facilitate collaboration between researchers from different fields by advancing interdisciplinary research and enabling them to tackle complex scientifi problems that cannot be solved by a single discipline, for example,

[20] All these EU challenges have been addressed by the Open Science Policy Platform (OSPP), the EU High-Level Advisory Group run by the European Commission from 2016–2020. See. [24] and also by different institutions, like LERU, YERUN, EUA, etc. See for example the document targeting Universities and Research Performing Organizations [25].

to address Sustainable Development Goals [33] or an extreme crisis like COVID-19 [34, 35]. The rights to research and to access research outcomes can help guarantee sustainability, innovation, and justice [18].

There are many studies, surveys and different approaches to identifying OS's challenges [10, 36, 37]. These challenges include issues related to data privacy and security, funding, data quality, data compatibility, data ownership and control, expertise in data management and analysis, etc. Other approaches focus on the challenges of real practice of OS, on the understanding, practicality, transparency, sharing, and replication from particular disciplines like biosciences or psychology [26].

Beyond new data-driven research approaches or the practice of OS inside a particular discipline, real global challenges come from the current traditional 'research business'. A paradigm shift is needed [7, 22], even a "profound shift in epistemology" [38]. Here we detail four challenges to OS becoming a default paradigm for new research: three urgent changes, plus the move to a real and fair framework of diversity, equity, inclusion, and accessibility principles.

3.1 Challenge #1: Change the Way We Communicate Science

Traditionally, scholarly communication has been mediated by academic journals and publishers, which act as gatekeepers for the publication of scientifi research. However, this system has been criticised for being expensive, slow, dysfunctional, and market-based, primarily serving the purpose of bringing profi to commercial publishers[21].

The oligopoly of a few scientifi publishers has become the most profitabl current legal business, with annual revenues comparable to Google, Apple, or Amazon[22]. This leaves researchers dependent on the "most profitabl obsolete technology in history"[23]. This approach is not good for scientifi communication, but by restricting access to the scientifi record it also risks losing the public's trust in science, undercutting global inclusion, and largely failing to realise the opportunities presented by the digital revolution. It seems that at the moment, misinformation and disinformation on scientifi advances are freely available online to all, while credible and authoritative scientifi information and data lie behind paywalls.

Scholarly communication faces many challenges, including information overload, limited access to scientifi knowledge, and quality issues like questionable research practices [39] or research reproducibility and integrity [40], among problems frequently discussed [41]. Innovative approaches to scholarly communication are needed to ensure that

[21] See the explanatory article published in *The Guardian* by Stephen Buranyi, in 2017 describing the scientifi publishing system. Is the staggeringly profitabl business of scientifi publishing bad for science?. Available in: https://www.theguardian.com/science/2017/jun/27/profitable business-scientific-publishing-bad-fo -science

[22] See. https://www.theguardian.com/science/2017/jun/27/profitable- usiness-scientific-publi hing-bad-for-science

[23] Academic journals: The most profitabl obsolete technology in history. This was the title of a post by Jason Schmitt in the Huffingto Post Blog, on December 2014. Available in: https://www.huffpost.com/entry/academic-journals-the-mos_b_6368204

scientifi research is shared and communicated effectively. Traditionally, the scientifi evaluation system forced researchers to focus on writing academic papers. Publishing a ‘paper’ has become an objective in itself, and researchers seem to be just ‘paper-makers’ instead of solving the world’s scientifi challenges.

The current Open Science/Open Access approaches maintain the ‘paper-centric’ model while embracing open-access publishing, renewing the business of publishers by charging for publishing (Article Processing Charges or APCs), or even worse, charging for reading as well as publishing (transformative agreements[24]), and generating other issues like the so-called ‘predatory journals’[42]. Another approach is to adopt new technologies, such as preprint servers, repositories, etc. allowing researchers to quickly and easily share their finding with the scientifi community before formal (paid) publication (preprints) or after the publication is issued in a journal with an embargo period (repositories). Different open access policies (Fig. 3), described by colours (gold, green, diamond, even ‘black’ considering rogue solutions such as Sci-Hub)[25], widely used, but they have not yet individually or collectively ensured all papers are openly available [43], nor do they seem likely to do so.

Paying for publishing —instead of paying for reading— only brings forward the payment, and a uniform cost is added to all research funding. The more predictable revenue stream no longer relies on anyone prioritising the money to buy journals. It primarily creates more profi for the big publishers, who charge for hybrid journals (the ones where researchers are encouraged to publish if they want promotion or funding). PlanS, cOAlitionS[26] and R&P (read and publish) transformative deals have unintentionally reinforced the power and the business of large publishers. As Science Business pointed out recently: “The big problem with open access publishing is that it’s expensive. Science is a big business, with more than $2 trillion spent on R&D each year, according to UNESCO, making the business of publishing research results a big cash cow”[27]. Solutions like diamond open access publishing platforms (e.g. Open Research Europe[28]) are a better option since they make research papers freely available to both readers and authors, so scholarly communication structures (articles/publications/publishers) are more sustainable and inclusive in the long term [44]. But retaining the centrality of the traditional paper also maintains the opportunity window for traditional academic publishers to

[24] Transformative agreements aim to transition subscription-based publishing to open access, but issues arise around the costs and sustainability of these agreements, as well as concerns about the impact on smaller publishers and potential conflict of interest. For a better understanding of transformative agreements, see this blogpost from Pandelis Pearakakis: https://pandelisperakakis.info/2021/05/07/what-are-transformative-agreements-and-what-to-know-before-using-them/

[25] See Lucy Barnes’ blogpost to review all the OA routes, including hybrid, bronze, libre and gratis: https://blogs.openbookpublishers.com/green-gold-diamond-black-what-does-it-all-mean

[26] https://www.coalition-s.org

[27] Science Business sumarized the EU council conclusions under the Swedish presidency https://sciencebusiness.net/news/Universities/leaked-eu-member-states-set-out-reform-scientific-publishin For the draft of the Council conclusions see: https://data.consilium.europa.eu/doc/document/ST-5997-2023-INIT/en/pdf

[28] https://open-research-europe.ec.europa.eu

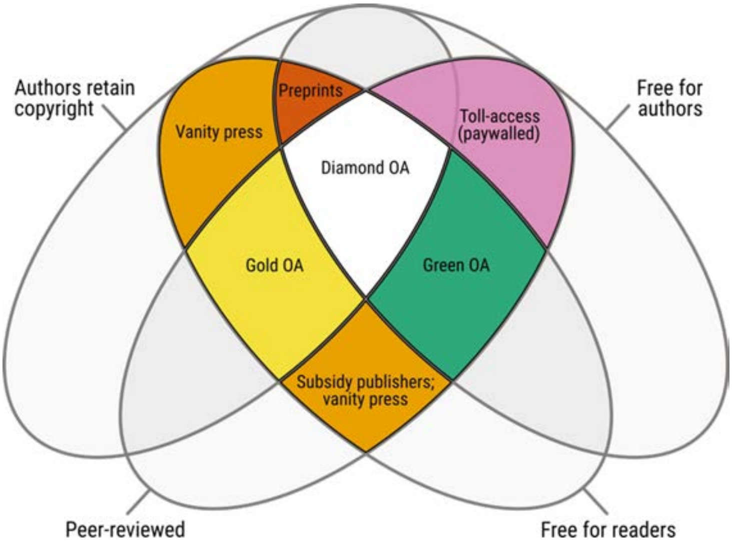

Fig. 3. Venn diagram highlighting the different levels of open access in scholarly publishing, as a function of cost to the readers and authors, copyright retention, and peer review (Farquharson, Jamie (2022): Diamond open access venn diagram [in SVG]. Figshare. Figure: https://doi.org/10.6084/m9.figshare.21598179.v).

continue to reap handsome profit while holding back scientifi progress through their outdated business models, whose effects have now become regressive.

A disruptive solution is (very much) needed, coherent with current technology and needs. Researchers need to cut out the whole notion of publishing, "get rid of papers[29]", pages, and journals, and return as much as possible of the outrageous costs that this outdated business extracts as rents to fund the work of research. While research papers have long been the cornerstone of scientifi communication, and they made sense 350 years ago —when the firs scientifi journal was created[30]— in the current context of digital transformation and new data-driven research, they are senseless and inefficient

The very notion of a "paper" should be completely overhauled. Research papers are often lengthy and difficul to understand. As a format, they are readily prone to errors that are not easy to detect[31]. This makes it difficul for researchers to keep up with the latest developments in their field and for citizens to understand the significanc of new findings We have reached a point where, perhaps with supervision, Artificia Intelligence can write papers for us. The most important outcome of research is not a fina article, but the hypothesis, the demonstrations, the data, and the methodologies,

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29 The Guardian reflecte again in April 2022 on the issue of scientifi publishing by Stuart Ritchie, The big idea: should we get rid of the scientifi paper?Available: https://www.theguardian.com/books/2022/apr/11/the-big-idea-should-we-get-rid-of-the-scientific-pape

30 https://royalsociety.org/journals/publishing-activities/publishing350/history-philosophical-transactions/

31 See: Ball, P. It's not just you: science papers are getting harder to read. *Nature* (2017). https://doi.org/10.1038/nature.2017.21751

often including software to analyse them. These factors open up the scientifi cycle and enable collaboration with researchers from different disciplines who can advance science more efficientl than at present, even if they do not normally follow academic journals in those areas.

Policymakers prioritize what they believe is best for scientifi research as a whole, but they may not take into account the needs and concerns of individual researchers 'all for the researcher, but without the researcher[32]. It is essential to ask actual researchers what they want, and how they can improve their research communication, without those proposals being provided on the researchers' behalf by commercial publishers. Recently, the Open Scholarship Initiative published the results of their "Research Communication Survey", where 90% of respondents selected some version of the answer "I think there are better ways of doing research communication" and 75% wanted to hear about and explore new ideas and policies [45].

3.2 Challenge #2: Change the Way We Assess Research and Researchers' Evaluation

This has always been the hottest core issue under the debate of what we need to truly implement Open Science: "to change the way we measure science[33]". We need a complete reset of the system for how research is valued, measured and assessed.

Along with the anachronistic scholarly communication system described above, contemporary research assessment is outdated and inappropriate for currently needed research. It provides existential support for the old-fashioned and dysfunctional paper-centric system, primarily enabling the unsustainable and disproportionately profitabl business around it.

Traditionally, scientifi research's quality and impact are evaluated using metrics such as the journal impact factor (JIF). JIF measures the frequency with which the average article in a given journal has been cited in a particular year. "JIF in policy and decision-making in academia is based on false beliefs and unwarranted inferences" [46]. But we cannot blame the system for using JIF in the evaluation procedures of researchers' careers and grants, unless we provide them with an alternative measure or mechanism. Quantitative metrics (JIF, h-index, etc.) have been largely criticised for being too narrow and for not accurately reflectin the true impact of scientifi research [47–51]. Many important contributions to science may not receive numerous citations, while studies with questionable methodology or data may receive a high number of citations simply because they were published in prestigious journals.

Alternative ways to assess a researcher's contribution to Science are also discussed: altmetrics, new indicators, next-generation metrics, etc. [52–55], but without a clear consensual approach. One potential approach would be to focus on alternative metrics including the so-called altmetrics [53] and/or social media metrics [56] such as the number of downloads and views of a research article, or the number of times a dataset has

32 See: Eva Méndez (@evamen) comments to Commissioner Moedas' speech on European Open Science Cloud (EOSC) Summit (June 2017):https://yerun.eu/wp-content/uploads/2017/07/Dr-Eva-Mendez-input-to-EOSC-Summit.pdf

33 Watch the statement in the Introduction video Conference Open Science 4–5 April 2016, Dutch Presidency EU2016: https://www.youtube.com/watch?v=C9a3Ap3yyak&t=277s

been reused in other research studies. But none of these alternative metrics (also not immune to certain problems or limitations) has been adopted consistently in the evaluation procedures. The only advance so far, is the particular and growing commitment of some institutions to adhere to the DORA declaration[34], Leiden manifesto[35], or more recently, the Hong Kong principles[36] and SCOPE principles[37]. All these declarations and principles pledge to reward more qualitative factors (sharing practices, peer review, students' advice and mentoring, etc.) and ground the evaluation on the researcher instead of the outputs —such as sole publications. These new approaches to embracing more qualitative assessments of researchers and research careers acknowledge the values of OS in establishing criteria beyond purely quantitative indicators, like the CAM (Career Assessment Matrix) define by the European Commission expert group [49]. This new trend tries to give room to everyone's talent in academia[38], as well as Responsible Research Assessment (RRA) centred on the researcher [57]. RRA[39] does not have a single universally agreed definition but it "is an umbrella term for approaches to assessment which incentivise, reflec and reward the plural characteristics of high-quality research, in support of diverse and inclusive research cultures" [58]. The recent launch of the Coalition for Advancing Research Assessment (CoARA[40]) marks a significan step toward the responsible use of metrics, and qualitative and comprehensive research evaluation. CoARA is a bottom-up initiative that resulted from the European Commission's facilitation to propose new approaches to research evaluation [59]. CoARA will seek and discuss alternative mechanisms to evaluate scientifi research, beyond traditional metrics, such as JIF, and focus on the actual impact and reach of research papers. This new approach places a greater emphasis on open-access publishing, data sharing, and collaboration, reflectin the growing recognition that these elements are critical components of high-quality scientifi research. At the time of writing, more than 450 institutions have signed the agreement[41] and more than 410 have also joined the coalition. By adhering to CoARA, the scientifi community can actively participate, pilot and move on to new research assessment. Scientists need this 'coalition of doers' but the technology to come up with real alternative research metrics is also needed. In this sense, the recently approved project GraspOS[42] (Next Generation Research Assessment to Promote Open Science) might come up with a technological solution that becomes

[34] San Francisco Declaration on Research Assessment (DORA). 2012: https://sfdora.org

[35] Leiden Manifesto for Research Metrics. 2015: http://www.leidenmanifesto.org

[36] Hong Kong principles for assessing researchers. World Conference on Research Integrity. 2019.https://www.wcrif.org/guidance/hong-kong-principles

[37] SCOPE Framework for Research Evaluation (iNORMS). 2021.https://inorms.net/scope-framework-for-research-evaluation

[38] See the position paper by the Universities in the Netherlands. 2020. Room for everyone's talent: towards a new balance in the recognition and rewards of academics: https://www.universiteitenvannederland.nl/recognitionandrewards/wp-content/uploads/2019/11/Position-paper-Room-for-everyone%E2%80%99s-talent.pdf

[39] https://www.leidenmadtrics.nl/articles/navigating-responsible-research-assessment-guidelines

[40] Https://coara.eu

[41] https://coara.eu/app/uploads/2022/09/2022_07_19_rra_agreement_final.pd

[42] https://cordis.europa.eu/project/id/101095129

an alternative to the current JIFs hiding also under paywalls in commercial data sources like Web of Science (WoS) and Scopus.

Research assessment is a complex area to change, and the approach must be multifaceted. It should be shaped by collaboration with researchers. It requires a new assessment equation that includes all the talents and merits that researchers and scientists have. Likewise, it should provide transparency and accountability, enable the assessment of interdisciplinary and cross-disciplinary research and its inclusiveness and equity. In addition, it is essential the impact of research on society and the environment, and recognising the increasing importance of OS it should promote better and broader collaboration. Research evaluation needs to be dynamic, fl xible, and innovative, leveraging the latest technology and trends to ensure that the best and most impactful research is being funded and recognised.

3.3 Challenge #3: Change the Way We Give Credit to Scientifi Contributions. A Step Forward Copyright

Intellectual Property Rights (IPR), such as patents and copyrights, play a critical traditional role in protecting the rights of researchers, publishers and/or innovators. These rights were developed to give researchers control over the use and dissemination of their work and provide a mechanism for them to be compensated for their contributions to the scientifi enterprise. However, they can also become a barrier to OS, as they may limit the ability of others to build upon and use existing knowledge. This can lead to decreased collaboration and information sharing, reducing public access to scientifi research in turn.

While IPR has long been seen as a critical component of scientifi innovation, there is a growing recognition of the fact that current approaches can be a barrier to OS [60]. The current EU legislative framework (the Information Society Directive[43], Database Directive[44] and the Digital Single Market Directive[45]) contains relevant provisions for access to and reuse of scientifi publications and data. In the current legislative landscape, researchers or their institutions are the firs copyright owners of exclusive rights over the scientifi publications they produce. However, publication in "high-quality" journals —which today is generally strongly linked to career development in academia— very often requires transferring those rights to publishers or giving them exclusive licences. The exclusive rights of copyright owners contrast with the fragmentation of exceptions and limitations to such rights. The current framework also poses challenges for the protection of researchers as authors and their interest in fostering the dissemination of knowledge. Although copyright rules were drafted to protect authors' creations, the widespread practice of researchers assigning copyright to publishers does not result in favouring the interests of those originally intended to benefit

There is growing recognition that a balance must be struck between protecting IPR and promoting OS [61, 62]. There are several approaches to move forward with the re-use of scientifi outcomes (not only publications but data). A traditional option is to adopt

43 https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX%3A02001L0029-20190606
44 https://eur-lex.europa.eu/eli/dir/1996/9/2019-06-06
45 https://eur-lex.europa.eu/eli/dir/2019/790/oj

more open recognition of moral rights with open licences, such as the Creative Commons licences, which allow researchers to share and build upon existing knowledge while still protecting their rights. In Europe, there is a specifi action (2) in the European Research Area to "propose an EU copyright and data legislative framework for research[46]". There are legislative proposals to introduce a "secondary publication right" for publicly funded scientifi publications, and non-legislative ones like those developed by funders (e.g. the Rights Retention Strategy, introduced by cOAlition S[47]) or by institutions (e.g. the Harvard model*, or the #ZeroEmbargo campaign run by LIBER[48]).

The future of IPR itself holds changes and challenges. As well as confronting the increasing importance of digital technology, and the growing importance of artificia intelligence, IPR policies are being reconsidered in light of the growing recognition of the value of OS and the concomitant need to balance the interests of creators and users, as well as the need to address issues related to globalisation including access and affordability. Current IPR standards and policies need to keep pace with technological developments, especially online, to avoid legal uncertainty negatively affecting knowledge production in research. It is urgent to address new copyright and IPR regimes to guarantee better intellectual protection that can support open, transparent and collaborative science.

3.4 Challenge #4: EDI-A (Equity, Diversity and Inclusion-Accessibility) in Open Science

Equity, Diversity, and Inclusion (or EDI) are increasingly important for research-performing organisations, and its principles are becoming crucial in Open Science, particularly since the UNESCO recommendation [20]. Embracing OS principles, researchers, and research institutions can help to build a more equitable and fair world. These recommendations and principles are well accepted on paper, but the reality is that we are far away from them being consistently and effectively applied in practice. Accessibility is one of the FAIR (Findable, Accessible, Interoperable and Reusable) principles applied to research data-sharing practices, and in general, to any research outcomes including software [63]. However, accessibility in this context is used to mean the availability of research outcomes. There is another significan sense of the term, commonly thought of as "web accessibility" due to the substantial and widely recognised work of W3C in this area*. This is critical to ensure the rights of people with disabilities to carry out research and to have equitable access to scientifi knowledge.

Sustainable Development Goal 10 focuses on reducing inequalities and promoting social, economic and political inclusion for all[49]. Participation in OS is not occurring on an even playing field The structural inequalities that shape our societies also manifest within academia, particularly in terms of unequal access to resources, and therefore, some operate within the Open Science space at a distinct advantage relative to others [64]. Current 'naive solutions' like "replacing big subscription deals with big APC deals simply flip inequity in accessing content with inequity in publishing content" [43].

46 https://era.gv.at/public/documents/4678/02_Copyright_and_data_legilsative_framework.docx
47 https://www.coalition-s.org/rights-retention-strategy
48 Https://libereurope.eu/zeroembargo
49 https://sdgs.un.org/goals/goal10

Failing to address structural inequalities directly, means that the advantages of those who are already privileged will grow, especially as they have a greater influenc on how OS is implemented [65]. A policy framework with practical implementation that ensures Equity, Diversity, and Inclusion (and access to people with disabilities) is needed if we are to achieve the Sustainable Development Goal 10 with regard to accessing scientifi advances.

4 Open Science and Artificia Intelligence: A Necessary Synergy

Open Science (OS) aims to make scientifi knowledge more accessible and transparent. Artificia intelligence (AI) promises to bring new insights and capabilities to scientifi research [66]. OS and AI are evolving at the same time, but we require them to evolve working together for the benefi of Science in the digital transformation era[50].

4.1 Combining OS and AI

We need to harness synergetic advances in OS and AI, to support the coming Open Scientifi paradigm. However, there are a number of challenges in doing this in a scientifi research scenario:

- Combining OS and AI can be technically challenging, since it requires researchers to manage and analyse large amounts of data using complex AI algorithms. This can require specialised training and resources, and it is difficul for researchers to keep up with the rapid pace of technological change in the fiel [67].
- OS relies on making scientifi data publicly available, which can raise concerns about data privacy and security. AI can be used to analyse this data, but it must be anonymized to protect individuals' privacy. Ensuring data privacy and security helps to build trust in OS practices and protects against potential ethical and legal violations. This is especially relevant in areas like medical, economic and sociological research, where sensitive personal information is often involved [69].
- AI can perpetuate and amplify biases in scientifi research. This typically happens when the overall data used to train AI algorithms is biased in some way. This is a significan concern in OS, where data is made publicly available and can be used by a wide number of researchers [68].
- The traditional 'paper-centric' model of scientifi publishing, with a heavy emphasis on research papers, is giving way to more innovative and accessible forms of scientifi communication. AI algorithms and tools like ChatGPT [66, 70] are playing an increasingly important role in scientifi communication, for example being listed as an author on research papers [6]. There is growing recognition that data itself is becoming the most valuable currency of scientifi research. "Data is essential for AI, as algorithms in these systems need large quantities of high-quality data to perform properly and to develop further by 'learning'. The continuous promotion of data quality within

[50] The European Commission is aware of this need on its priorities for funding the European Open Science Cloud (EOSC) https://cordis.europa.eu/project/id/101058593 https://ai4eosc.eu/ See. https://ai4eosc.eu/

organisations when using (open and FAIR) data for AI is therefore essential to gain reliable insights[51]". By embracing OS, and moving to place a greater emphasis on sharing research outcomes as FAIR data than on the production of papers, scientists can continue to advance our understanding of the world and improve the quality of scientifi research.

4.2 New Scenarios for Research Integrity

Technology is not neutral. The use of AI in scientifi research presents many opportunities, but also several challenges, particularly concerning research integrity (See also Chapter 10, in this volume): the principles of honesty, trustworthiness, and transparency that underpin the scientifi process. In the context of AI, these principles must be upheld, especially as AI systems become increasingly complex, and their reasoning becomes difficul to reproduce. Hence, the urgent need for a culture of Responsible AI [71].

Examples of how research integrity can be compromised by AI in scientifi research are (1) bias in training data (if the training data used to build an AI system contains biases, many AI systems perpetuate and amplify these biases in their results); (2) lack of transparency (many AI systems, particularly deep learning models, can be difficul to interpret, making it difficul for researchers to understand why the AI system is making certain decisions); (3) overreliance on AI results (as AI systems become increasingly sophisticated, there is a risk that researchers become too reliant on the results produced by these systems, even if they cannot understand how the AI system reached these results); and (4) misuse of AI systems. There is a risk that AI systems may be used in ways that violate ethical principles or compromise research integrity [72].

5 Conclusions: Open Science for Today (and Tomorrow)

The old-fashioned practices (journals, papers, impact factors, h-index etc.) are designed to create and maintain the 'publish or perish' status quo that drives researchers' careers and academic publishers' profit all over the world. The gold open-access approach will leave a lot of researchers, countries and poorly funded disciplines behind. It often seems that a researcher's fundamental goal is 'to write papers', rather than understanding and findin solutions for global issues. By embracing OS and findin innovative approaches to scholarly communication, the scientifi community can continue to advance our understanding of the world and improve the quality of scientifi research. In this chapter, we have revisited the main changes necessary for a research paradigm built around the practice of Open Science.

The traditional and current publication and evaluation system was conceived for research in a qualitatively different era, and it is not suited to contemporary and emerging needs of the scientifi "system". A new research evaluation system must evolve to reflec changes in research practices and emerging technologies, ensuring that it remains relevant and effective. We can not simply replace the JIF with another (more updated,

[51] AI and Open Data: a crucial combination (data.europa.eu, 2018): https://data.europa.eu/en/publications/datastories/ai-and-open-data-crucial-combination

but equally fl wed) metric or indicator. We require a conclusive system that, applying all the current technologies (AI, blockchain, etc.) can come up with an updated and efficien mechanism to evaluate current science, in a twofold sense: assessing all that is needed to be evaluated in the current research performance and applying all the current technologies.

Digital transformation is about changing the entire system using web-era technologies and principles. Every change entails an effort, and the real epistemological shift might be uncomfortable for incumbents (publishers, but also a proportion of academics who are comfortably positioned to benefi from the status quo). To promote open access and redesign the current system, simply switching from printed journals to digital PDFs is not enough. Business models must be revised to better support open access, and outdated metrics should be reevaluated with a sense of responsibility. Additionally, IPR legislation should include more exceptions to better align with these changes. In the interest of an equitable society, equipped to develop and apply scientifi knowledge to the pursuit of its goals, we need fundamental changes in the whole ecosystem that determines the way we do and communicate research.

Of course, there are many other challenges ahead to make Open Science a holistic reality (citizen science, FAIR data in the data research infrastructures like EOSC or the research integrity), but the ones detailed here are urgent changes needed to firml fulfi OS goals.

Acknowledgement. The authors want to thank Charles Nevile for English proofreading and his valuable suggestions for the fina version of this document.

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