F1000

The future is open: academic research in the digital age

Discover the rise of open research and learn how digital advances have, and will continue to, change academic research.

Introduction

The past few years have seen major changes in the way researchers access, publish, share, and assess research. Open access publications have surpassed subscription-only publications; funders and governments increasingly adopt open access and data sharing mandates; and there is a drive among the community at large to make all research outputs as open as possible, and as closed as necessary.

In a post-COVID-19 world, where there are increasing demands for fast publication and for science to keep pace with social demands, open science offers not just 'quick' publication, but a recalibration of research culture, privileging multilateral collaboration and input, together with transparency and recognition for all contributions.

As we move further towards an open future, it's time to take stock and ask, *'How did we get here?'* and perhaps more importantly, *'Where are we going?'*

Based on contributions from F1000 experts:

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What is open research?

Open research is a set of principles and practices that prioritize openness, transparency, and collaboration across the entire research cycle. Advocates of open research believe that all research outputs should be freely available and reusable to support reproducibility and equal access to knowledge. This includes the free availability of research results, data, and software.

**Open Access (OA)** is the process of making content freely and openly available, with clear licensing that enables reuse.

The different types of open access include:

- **Gold OA**

- **Diamond or Platinum OA**

- **Green OA**

- **Hybrid OA**
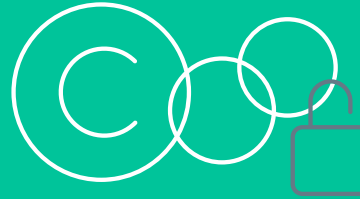
Gold OA
A publisher-mediated form of open access where the final published, typeset, and copyediting version of an article is made permanently and freely available upon publication. Authors are typically required to pay an article processing charge (APC).
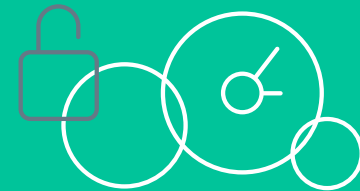
Diamond or Platinum OA
Diamond or Platinum open access refers to publications that are free to authors to publish with and readers to access. These publications are usually supported by institutions, or national or regional infrastructure.

Green OA
Green open access, also known as self-archiving, is when you publish an earlier version of your article in an accessible repository. An embargo period usually applies before you can archive or share your manuscript.

Hybrid OA
Hybrid open access refers to publications that operate a hybrid model, where researchers can pay to publish an open access article in an otherwise non-open access publication.

Why open research?

In the digital age, open research is more pertinent than ever. Scientific research depends more and more on the sharing and understanding of both text and data. The work of researchers and funders around the world is becoming increasingly aligned with producing reproducible research that is freely accessible to all. But what has contributed to this shift in the publishing landscape?

The answer is twofold. On the one hand, the open research movement continues to gain momentum because of the demonstrable impact it has on society by accelerating the pace of scientific discoveries.

The COVID-19 pandemic is just one example of where open research practices, including open data, became paramount. Through open research, the academic community came together to provide immediate, easy access to essential research and inform evidence-based health responses in real-time.

The pandemic drove a huge increase in open science practices. More than 30,000 pre-prints were published in 2020 globally. Many of them reported key discoveries that influenced health policy. These included early transmission data which fed into government policies around things like isolation periods. The rapid dissemination of such data was very beneficial at the early stages of the pandemic when we knew very little about COVID-19.

James Barker
Associate Publisher

On the other hand, open research is equally beneficial for individual researchers and their careers. Researchers that publish their research openly benefit from:

Faster routes to publication

Publishing open access allows researchers to publish their work more quickly through publishing platforms and pre-print servers. Faster publication can be a significant advantage when it comes to grant applications and promotions.

Increased views and downloads

Studies have shown that open access articles are more widely viewed and cited. According to a recent international survey of early career researchers, increased visibility and readership are the strongest draw to open access publishing for many researchers.
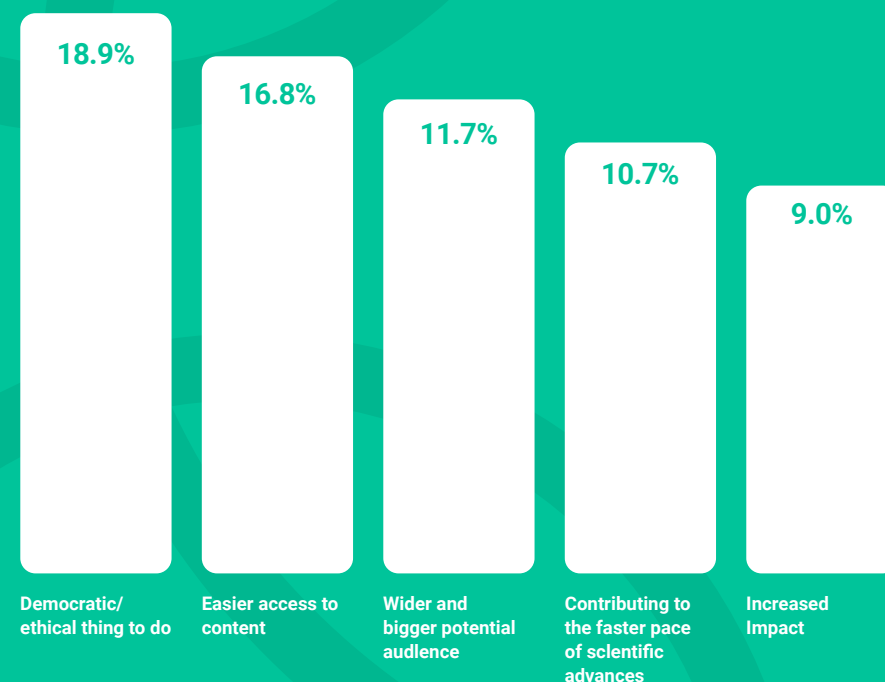
Wider public engagement and influence

Researchers publishing openly amplify the impact of their research by helping those beyond academia to discover, understand, and apply the findings. This includes policymakers, practitioners, and non-governmental organizations.

Greater collaboration

When research isn't kept behind a paywall, researchers have a greater chance of facilitating collaboration and building connections with other researchers across institutions, regions, and disciplines.

Top reasons for publishing open access*
By number of mentions

| 18.9%	16.8%	11.7%	10.7%	9.0%
Democratic/ethical thing to do	Easier access to content	Wider and bigger potential audience	Contributing to the faster pace of scientific advances	Increased Impact

The rise of open research

Global adoption of open research publishing and practices has increased dramatically in recent years. The past decade has seen a move from **70% of all publishing being closed access**, **to 54% being published open access**. In other words, open access publications have surpassed subscription only publications.

Plus, it isn't only uptake of open access publishing that is increasing. Researchers are increasingly opting to share their data openly, in an effort to make research more reproducible and adhere to publisher and funder policies.

Open access vs. closed access publications
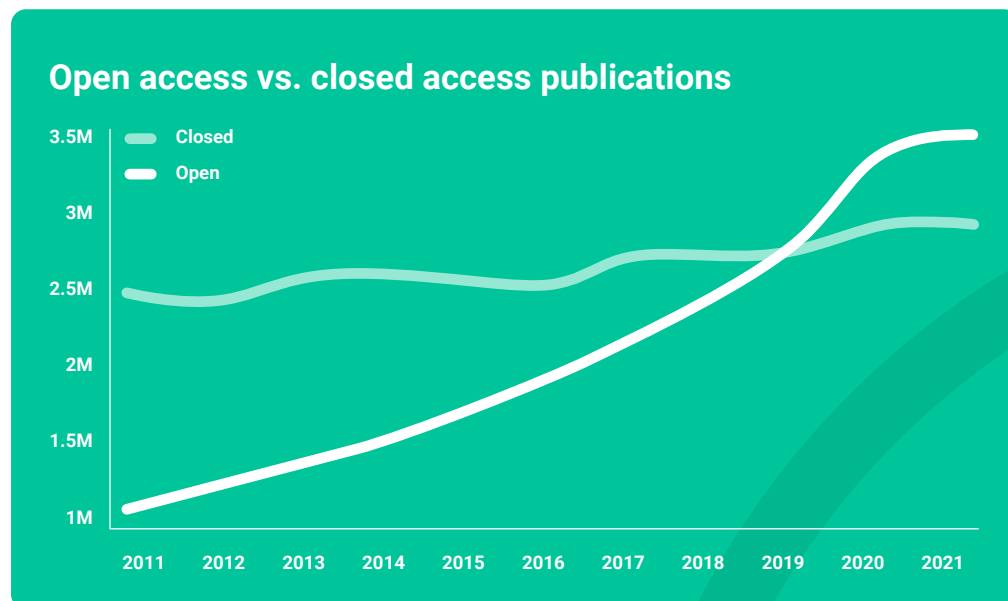
Open access vs closed access publications, based on data from **Halfway to happiness — what the OSTP update means in the grand scheme**: https://knowledge.figshare.com/article/halfway-to-happiness-what-the-ostp-update-means-in-the-grand-scheme. Accessed 3/17/2023.

Key insights

54% of research is published open access

70% of open access papers were Gold OA in 2021

4/5 researchers are in favor of making data sharing standard practice
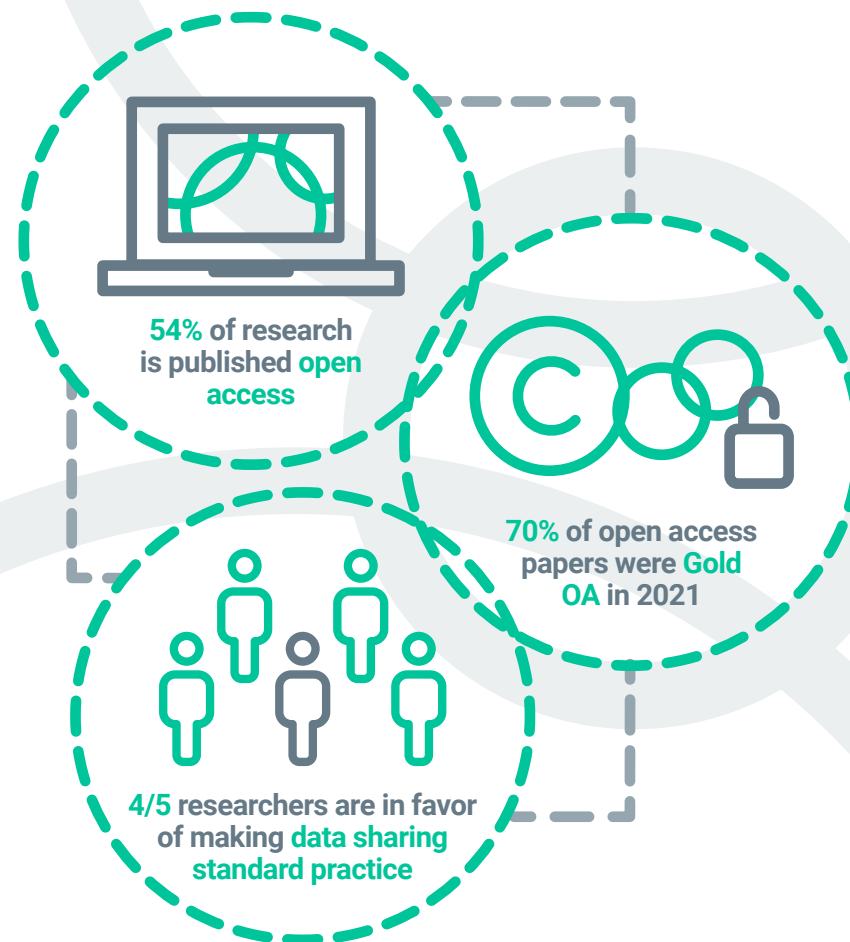
Policy leads the way for open research

So, what has contributed to the rise of open publishing?

As the benefits of open research become increasingly clear, more and more open access policies and mandates are coming into play at the governmental, institutional, and funder levels. Open access policies can require or recommend researchers provide free, immediate, and full access to published and peer-reviewed research.

Europe and the Americas continue to be the leading regions for open access adoption with the first and second highest number of open access policies respectively. Together, these regions account for over 85.9% of open access policies.

However, this could change in the coming years, as many experts predict that Asia will follow the course set by the United States and introduce open access mandates. Given that Asia is home to four of the top 10 research producing countries — **China**, **Japan**, **South Korea**, and **India**, this could have a dramatic impact on open access output.
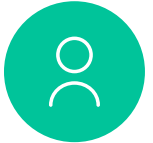
Open access policies by country
Number of policies

USA (138)
UK (117)
Spain (31)
Australia (33)
Turkey (41)
Finland (29)
Germany (27)
Canada (27)
Italy (23)
Portugal (22)
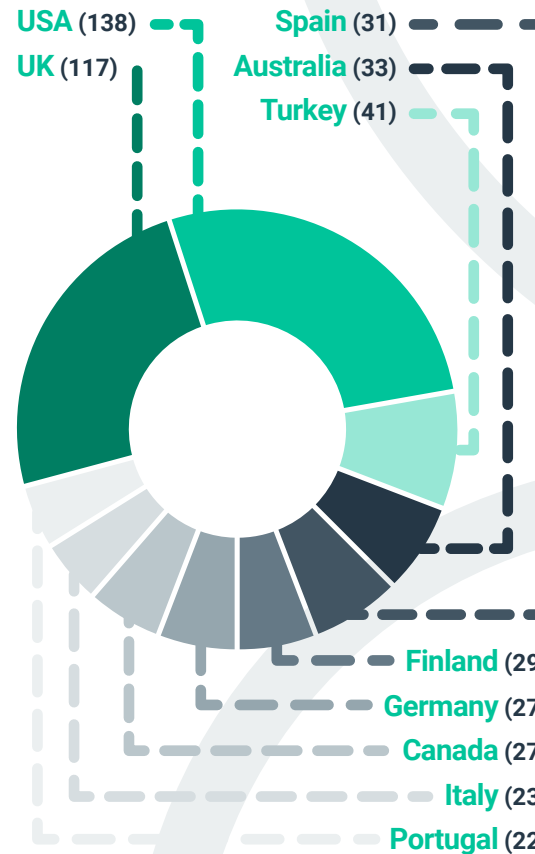
Open access policies by continent
Number of policies

Europe (463)
Americas (198)
Asia (49)
Oceania (40)
Africa (19)
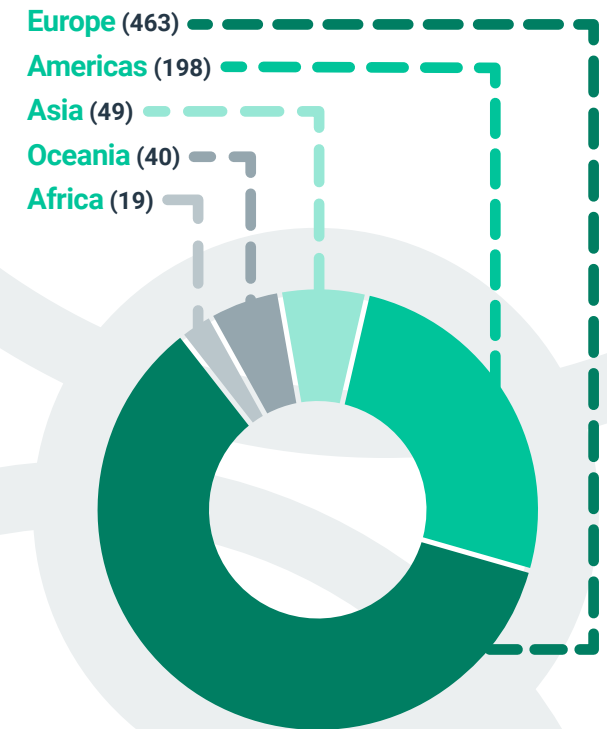
Who is responsible for the growing number of open access policies?

As highly influential stakeholders in the research ecosystem, large private and public funders are increasingly requiring funded research to be made openly available. According to the Registry of Open Access Repositories Mandatory Archiving Policies (ROARMAP) over 760 open access policies currently exist internationally.

In Europe, **Plan S** has been a major influence on the ascent of open research. Launched in September 2018, Plan S is an OA initiative launched by cOAlition S, a European consortium of organisations that conduct and fund research. Plan S requires publications that derive from research funded by public grants to be published OA. Signatories of Plan S include the World Health Organization, the Gates foundation, and Wellcome.

Similarly, in the United States, both the **Office of Science and Technology (OSTP)** the **National Institutes of Health (NIH)**, have played a huge role in advancing open access and data sharing among researchers. In 2022, the OSTP issued guidance to make federally funded research freely available. In 2023, the NIH began enforcing its Data Management and Sharing Policy which requires researchers to share their research data.

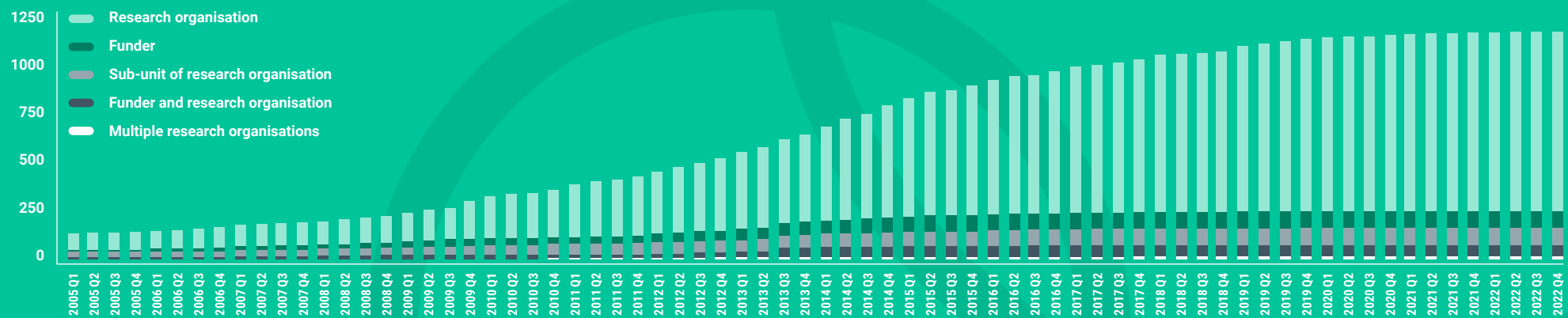Institutional mandates are generally less restrictive and tend to vary from one institution to another. Funder open access mandates are usually stricter: they impose a contractual obligation to publish open access. Researchers who fail to comply with funder open access mandates may lose access to their funding.

Policies adopted by Quarter

Legend:
- Research organisation
- Funder
- Sub-unit of research organisation
- Funder and research organisation
- Multiple research organisations

* Open access policies adopted by quarter, based on Data from ROARMAP: https://roarmap.eprints.org/. Accessed 3/17/2023.

Global adoption of open research

Fueled by new open access policies and a drive to reap the benefits of open research publishing, global adoption of open research has dramatically increased over the past decade. But how does open access output differ between countries?

The countries producing the most research outputs globally are:

1. **United States (US)**

2. **China**

3. **United Kingdom (UK)**

4. **Japan**

5. **Germany**

Figures from 2012–2022 show that the UK published the greatest proportion of its research open access – **over 61%**. They are followed by the US, where **over 46%** of published research is published open access. The US consistently leads contributions to global open access output, at **over 18%** of global open access publications.*

* The percentage of research published open access between 2012 and 2022, based on Dimensions publications data.

Articles published open access between 2012 and 2022
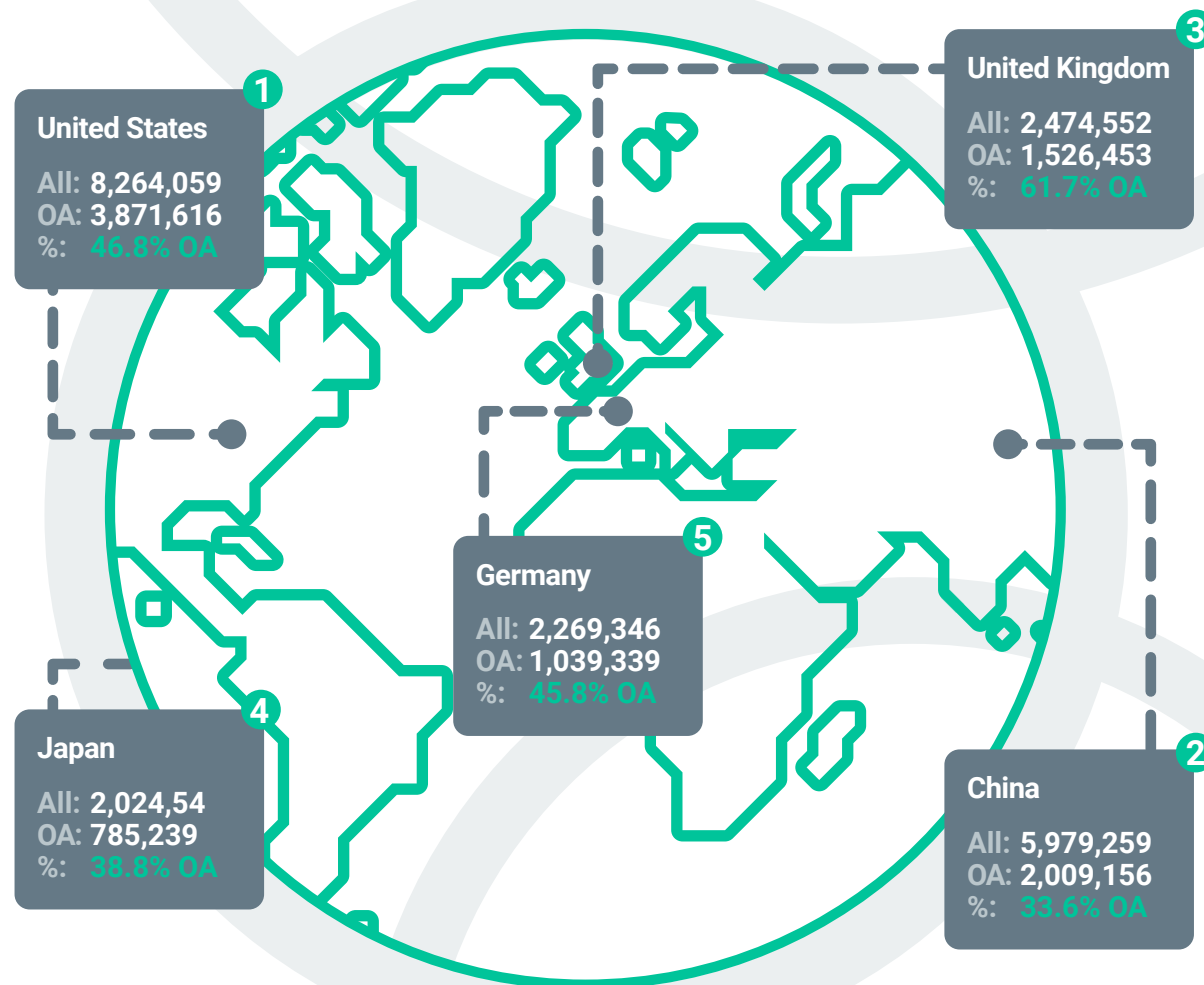
1 United States
All: 8,264,059
OA: 3,871,616
%: 46.8% OA

3 United Kingdom
All: 2,474,552
OA: 1,526,453
%: 61.7% OA

5 Germany
All: 2,269,346
OA: 1,039,339
%: 45.8% OA

4 Japan
All: 2,024,54
OA: 785,239
%: 38.8% OA

2 China
All: 5,979,259
OA: 2,009,156
%: 33.6% OA

* Open access policies adopted by quarter, based on Data from ROARMAP: https://roarmap.eprints.org/. Accessed 3/17/2023.

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Open research: the evolution

2012 — **UK Finch Report** recommends Gold OA for publicly funded research

2005 — **Wellcome Trust** mandates depositing Wellcome-funded research with PubMedCentral

2003 — First native OA journal – **PLOS (The Public Library of Science)**

2002/3 — **Budapest Open Access Initiative** and **Berlin Declaration on Open Access**

2000 — First open access publisher, **BioMedCentral**, launches

1991 — Archives for preprints launches – **arXiv.org**

2013 — **F1000** launches world's first open publishing Platform, **F1000Research**

F1000 launches the industry's first mandatory open data policy on **F1000Research**, framed around what later would become the FAIR principles

2015 — **Bill & Melinda Gates Foundation** mandates Gold OA

2016 — **NIH** mandates OA for its research funding

Wellcome Trust launches **Welcome Open Research** with F1000

FAIR data guidelines established

2023 — **U.S. NIH Data Management** and **Sharing Policy** goes into effect

2022 — **U.S. OSTP** issues guidance to make federally funded research freely available

2022 — **Howard Hughes Medical Institute** OA mandate comes into effect

2021 — **WHO** requires all WHO-authored and WHO-funded articles are OA

2018 — **Plan S** launches, supported by **European cOAlition S** research funders and performers

2017 — **Bill & Melinda Gates Foundation** launches **Gates Open Research** with F1000

Preprint servers changed the pace of research

A preprint is a version of a research article that authors can share online before submitting it to a journal for peer review and publication. Preprint servers have changed the pace of research, providing an outlet for authors to share their findings openly and without delay.

However, preprints are not thoroughly reviewed by experts before they are shared with the research community and the public. Peer review is a hallmark of the scientific process, serving as a safeguard for research accuracy and integrity. This has led to concerns that unreviewed research findings could be generalized, misunderstood, or sensationalized, in traditional or social media.

Despite concerns around sharing research before peer review, physics, mathematics, and economics researchers have been sharing their work through preprints for years. However, the COVID-19 pandemic created an overwhelming need to accelerate scientific communication and drove many biomedical researchers to publish preprints for the first time. In 2020 alone, more than **30,000** preprints were published globally. Many of them reported key discoveries that influenced health policy and governmental responses to the pandemic.

Authors who choose to publish in traditional journals can be subject to months or even years of waiting for their research to be peer reviewed and published. Preprints and preprint servers, however, offer an alternate route for sharing findings with the world. Speed is the primary draw for researchers sharing their work on preprint servers; But preprints can also be a useful means of gathering feedback and establishing attribution for who came up with an idea first. Plus, preprints are highly discoverable and easily citable. Preprints are published fully open access and assigned a unique digital object identifier (DOI).

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Open publishing venues enabled the sharing of all research outputs

The growth of open research publishing venues and megajournals has enabled researchers to publish various research outputs that can undergo peer review and be cited by other authors. Such publishing venues do not reject articles for lack of novelty or significance so long as they are original and scientifically sound.

As a result, researchers can share all their research outputs beyond the traditional research paper, including but not limited to **Study protocols**, **Registered reports**, **Systematic reviews**, **Method articles**, **Brief reports**, **Opinion articles** and **Case studies**.

In recent years, F1000 has introduced several unique article types to support authors in telling the whole story of their research. These article types include Data Notes, Genome Notes, Software Tool Articles, and Policy Briefs.

The benefits of sharing a myriad of article types are twofold. On the one hand, publishing multiple, citable article types throughout a research project allows authors to expand their academic footprint and get credit for all their work. In turn, this adds transparency to their research process and opens the door for greater impact and visibility.

On the other hand, publishing more research outputs to the version of record has the potential to aid the advancement of science mor generally by reducing research waste and enabling others to build upon existing work.

Research outputs

Study protocols

Registered reports

Systematic reviews

Method articles

Brief reports

Opinion articles

Case studies

New metrics provided a new means of assessing research impact

Research assessment will always be an essential part of academia. Institutions and funders need to assess research integrity, rigor, and impact to determine grant allocation, promotion, tenure, and other key decisions. The past decade has seen a great deal of innovation in research assessment, including new metrics and technology to measure research impact.

The Declaration of Research Assessment (**DORA**), established in 2013, paved the way for expanding the way we think about and assess research impact. DORA emphasizes the need to assess research on its own merits rather than based on the journal in which the research is published. As a result, institutions, funders, and publishers alike are increasingly turning to article-level metrics and qualitative indicators of research impact, such as influence on policy and practice.

Alternative metrics, or 'altmetrics' have evolved over the last few years as a way of monitoring the online attention surround a research output – be it a traditional research paper or other article types, such as study protocols, registered reports, and more. **Altmetric**, an online research engagement tracking platform, has made such research assessment reform possible by collating a more holistic view of the mark research has made on the world. Altmetric reports detail the number of times an article has been mentioned on social media platforms, blog posts, news outlets, policy documents, and more.

But Altmetric paints a bigger picture than numbers alone. By diving into the underlying data, users can get a better sense of who is engaging with their research, how they interpreted it, and how they are using it, often long before it is likely to be cited in other publications. As a result, altmetrics can potentially change how we understand the impact of research in academia and beyond.

Social media opened the doors for greater collaboration and sharing

Social media platforms have revolutionized how academics publicize their research and engage with people beyond their institutions. Although unfamiliar to some researchers, social media is an invaluable tool for collaborating with others and increasing the visibility of research.

ResearchGate and Academia.edu are social networking sites for scientists and researchers to share papers, ask and answer questions, and find collaborators. Among the social media platforms popular with the public, **Twitter** is arguably the standout for researchers looking to engage with the broader research community.

#AcademicTwitter is just one area of Twitter that connects academics to each other, but also to journalists, policymakers, leaders, and the public. Plus, many subject-specific communities exist on Twitter for researchers to explore and engage with.

Beyond the Twittersphere, researchers also use other social media platforms, including Facebook, Reddit, and even TikTok. As such, knowing how to present the key findings of their work in plain, yet engaging language can be key to raising researchers' profiles and the visibility of their research.

How researchers can use micro-blogging platforms

Connect with others in their discipline

Exchange ideas and pose questions

Keep up to date with new research

Promote their research article

What does the future research ecosystem look like?

The future of research is undoubtedly open. But how will open research continue to evolve over the next decade? Our experts weigh in on what the future research ecosystem might look like:

Greater value on research content over journal reputation

What you publish, not where you publish, is increasingly becoming the new norm. A journal's reputation is retrospective, so on its own, it cannot tell you the influence an individual piece of research will have in the future or what sort of change a study might lead to regarding real-world impact. With the dissemination of research being more readily shared through preprints, we are starting to see instant value directly associated with the research article through open peer review, data availability, and clear information around the ethics and integrity of a piece of work. This additional context and transparency build more trust and deliver much more value to the reader as they have everything they need to make their own judgment on a research output without relying on a journal brand.

Michael Markie
Publishing Director

Increased automation in the peer review process

As artificial intelligence (AI) advances I think it will become a larger part of the peer review process. However, AI should be used to support human validation, not replace it.

Currently reviewers are often asked to assess an article in a myriad of areas that can and should be automated in the future and assessed before an article is sent to reviewers. Reviewers will then be free to focus where their true expertise lies: the academic content of the article.

This will not only improve the speed of peer review and the reviewer experience, but also allow for more rigorous, objective, and consistent quality and ethics checks, supporting a more robust and trustworthy publishing system.

Eleanor-Rose Papas
Senior Editorial Ops and Peer Review Manager

Broader adoption of data sharing policies and data peer review

Journals and funding agencies are now catching up in terms of stringent data sharing policies. Policy changes on data sharing coming from the NIH and OSTP last year will have a huge impact on data sharing in the US, and we're already noticing a trend towards stronger data policies from funders globally. These changes support an open research ecosystem where researchers expect to be asked to share data as they interact with various stakeholders, helping to make data sharing the norm. Plus, although peer review of the research data underlying a paper's findings is not yet standard across all publishing outlets, we believe that it has a crucial role in supporting research integrity, upholding the principles of open science, and enhancing the replicability of research findings.

Rebecca Grant
Head of Data and Software Publishing

Wider adoption of open peer review

I believe that that the future of academic publishing and peer review lies in open and transparent practices. We are already seeing increased recognition of assorted open peer review models and I would be very surprised if that did not continue as more disciplines commit to open research practices. There is increased focus on ensuring the integrity of academia and academic publishing, and open peer review facilitates open discussion and fosters trust in research. As open review is embraced more widely, it'll also contribute to more open and constructive discourse generally, which can only benefit academia. The advantages of publishing both peer review reports and reviewer identities are apparent. As the practice becomes more widespread, I expect to see more recognition of the value of peer review and the effort that underpins it.

Eleanor-Rose Papas
Senior Editorial Ops and Peer Review Manager

More efficient training on rigorous research practices

Given the role of scientific publication in academia, changes in how work gets published can have direct effects on how the work is conducted. We can see great examples of this through data mandates and reporting guidelines, such as CONSORT, PRISMA, and ARRIVE. Knowing that you have to share your data at the point of publication may lead an author to curate their data continuously throughout their project. By setting these expectations for rigorous reporting we can support the training of rigorous research practices through online courses, checklists, and guidelines that will hopefully mean these practices become the norm. This process can become more efficient by providing this information to early career researchers to support their development and nurture these habits from the beginning of their career.

James Barker
Associate Publisher

Our mission at F1000 is to accelerate the reach of knowledge and put it in the hands of those who will shape the future.

Our open research publishing venues offer researchers:

The chance to publish a broad range of non-traditional research outputs.

Expert, post-publication open peer review.

A robust open data policy to support reproducibility.

Transparent, low-cost article processing charges (APCs).

Responsible, comprehensive article-based metrics.

Let's publish openly together.

F1000 empowers researchers to publish openly, quickly, and with impact.

F1000's unique open publishing model lets researchers take the lead on what, when, and how to publish research findings.

See why thousands of researchers worldwide are publishing openly with F1000.

Why publish with F1000?

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