# The Need for Open Science

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## ABSTRACT

Open Science is about sharing knowledge where research data and its underlying methods and processes are made available "freely" for reuse, redistribution and reproduction by those other than the researchers themselves. The availability of these data publicly should promote the translation of research output into innovation and new technologies. In addition, making research data and knowledge publicly available to others would help to build trust on the research findings and could support public policies and further investments.

**Keywords:** Open Science; Open Access; Open Platform

## 1. Introduction

Scientific advancement has led to the economic, technology and societal progress of humanity. Many scientific discoveries and innovation such as vaccination for polio and invention of mobile phones have resulted in better life for humankind. The pace of science and its discovery is moving very fast with the advancement of modern science and technology. Particularly, computer and internet-of-things has enabled a vast number of scientific and research reports being published annually. However, most of these reports are not properly verified resulting in many non-reproducible results and data. For example, in an independent attempt to replicate selected results from a number of "high-profile" papers in Cancer Biology, researchers could replicate only 40 percent or less of the results reported (Davis et al., 2014). In a report in Nature Reviews Drug Discovery, Prinz and his co-workers questioned the reliability of published data on potential drug targets (Prinz and Asadullah, 2011). This "reproducibility crisis" has led many scientists to push for ways to improve scientific reporting to increase reliability. One way to do this is through "open science".

Open Science means that not just the scientists, but teachers, policymakers, journalists and other non-scientists, would have access to the research data and materials. Since most research is funded through public funds and tax-payers money, allowing anyone access to study these data would increase the value of every penny invested (Nielsen, 2011).

One of the earliest well-known examples of Open Science is the Human Genome Project which started in 1990 (Hood and Rowen, 2013). Throughout the course of the project, the scientific community widely

shared the data on the human genome. In order to encourage optimal collaboration, they also kept a moratorium on publishing. Open Science has enabled the scientists involved to decode the human genome in less than 15 years. In another example of Open Science, "brain-sourced" research, Tim Gowers, a mathematician at Cambridge University started the Polymath Project where he took an unsolved mathematical problem, published it in his scientific blog and invited everyone to contribute in solving the problem (Polymath Projects, 2019). On-line contributors were able to solve not just Gower's original problem, but also harder problem that was included the original as a specific example in only 37 days after the start of the project.

European Union has funded several initiatives which have led to steady progress towards Open Science (Beagrie and Houghton, 2016). One good example is the 'European Lead Factory' project under the Innovative Medicines Initiative (IMI) (European Commission, 2019). In this project, academic and industry partners pooled together around half a million compounds (chemical molecules) which are made publicly and freely available in a repository to any scientist who wants to screen and validate potential new drug targets.

The ecosystem underpinning Open Science which began with the World Wide Web or WWW is evolving rapidly. There are many social network platforms available for scientists and researchers to use and validate research data in a "brain-sourced" way (Nielsen, 2011; Nielsen, 2012; Vignoli et al., 2014; Crouzier, 2015). Several platforms, which are available for open access for scholarly publications to facilitate Open Science eco-system, are shown in the Table 1.

**Table 1:** Some Platform for Scholarly Publications for Open Science.

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| Academia.edu | A US-based platform for sharing of research papers. Academic.edu monitors the impact of these research and tracks the research of academics they follow. More than 30 million academics are signed up to the site by January 2016. A recent study reported that papers uploaded to Academia.edu receive a 73% boost in citations over five years. |
| Research Gate | This is a platform based in Berlin with virtually similar functions to Academia.edu and had about 8 million user and 80 million publications in January 2016. Research Gate generates a Research Impact Factor for the uploaded documents of researchers, based on factors such as 'classical' citations and on the number of downloads by other users. |
| Mendeley | An Amsterdam-based reference manager owned by the Elsevier publishing company has around 3 million users (June 2014). Mendeley allows for open annotation and generation of bibliographies. |
| Figshare | An online digital repository supported by Digital Science (a division of Macmillan Publishers). In Figshare, researchers can make their research outputs available in a citable, shareable and discoverable manner, including figures, datasets, images and videos. |

| F1000Research | This is an Open Science publishing platform for life scientists which offers immediate publication without editorial bias and publishes all scientific research within a few days. F1000Research uses an author-led process with open, invited peer review of articles conducted following publication of the research work. It focuses on scientific soundness rather than novelty or impact and all published research articles must be accompanied by the data on which the reported results are based. This is critical to enable reanalysis; replication attempts and data reuse. |
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There are currently numerous data repositories worldwide to support Open Science. These repositories may be called data centers, data archives, or scientific databases and are often divided into three categories:

i) Institutional Repositories (IRs) are affiliated with an institution such as the Digital Repository (DR-NTU) at Nanyang Technological University, Singapore.

ii) Domain-specific or Disciplinary Repositories (DRs) are discipline-specific and usually operated by a professional organization, a consortium of researchers, or a similar group.

iii) General-purpose or Open Repositories (ORs) which allow researchers to deposit and make their data available regardless of disciplinary or institutional affiliation. Some examples of this category of repositories are listed in Table 2.

**Table 2:** Examples of General-purpose Data Repositories Supporting Open Science

| Zenodo (Zenodo, 2019)  https://zenodo.org | This platform was created in 2013 by OpenAIRE and CERN as an all-purpose, open repository for all scholarship, enabling researchers from all disciplines to deposit publications, datasets and other research artifacts such as code, posters, presentations and share their research outputs, regardless of size or format. Free to upload and free to access for researchers to upload files up to 50 GB. |
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| The Australian Research Data Commons (ARDC) (Australian Research Data Commons, 2019)  https://ardc.edu.au/services/ research-data-australia/ | The Australian Research Data Commons (ARDC) was formed on 1 July 2018 which is an initiative that enables Australian research community and industry access to nationally significant, leading edge data intensive e-Infrastructure, platforms, skills and collections of high-quality data. ARDC provides high capacity digital data storage for nationally significant collections, cloud computing, collection curation and data management resources, as well as national catalogue, identifier and vocabulary services. |
| OSF (Center for Open Science, 2019; OSF, 2019)  https://osf.io/ https://cos.io/ | OSF is a free, open platform to support research and enable collaboration developed by Center for Open Science (CoS) whose mission is to increase openness, integrity, and reproducibility of research. |

| European Data Portal (European Data Portal, 2019)<br><br>https://www.europeandataportal.eu/en/resources/training-companion/open-data-platforms | The strategic objective of the European Data Portal is to improve the accessibility and increase the value of Open Data. This portal also enables metadata of Public Sector Information available on the public data portals across European countries to be harvested. |
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| Open Research Data Platform Switzerland - ORD@CH (ETH Zürich, 2019)<br><br>https://sis.id.ethz.ch/researchdatamanagement/service-ordch.html | ETH Scientific IT Services with collaboration of partners from academia and industry has developed a publication platform for open research data in Switzerland (ORD@CH), based on the open-source data publication system, CKAN. This platform has been made as a permanent infrastructure for sharing open research data in Switzerland since 2016. The ORD@CH platform provides a meta-data catalog for the publication of research data from life sciences, social sciences as well as humanities and other domains. |
| Peking University Open Research Data Platform (Peking University Open Research Data, 2019)<br><br>https://opendata.pku.edu.cn/ | The Peking University Open Research Data Platform was developed based on the "standardization of property rights protection" and with the purpose of "advocating open science" by promoting openness, exchanging, and sharing of research data. This platform provides researchers with the management, release, and storage services of research data, encourages researchers to open and share data, and provides data users with browsing, retrieval, and download services for research data, and promotes the dissemination, reuse, and standardization of research data. |

## 2. Several Global Initiatives of Open Science Policies

On 22nd October 2003, The Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities were launched (Max-Planck-Gesellschaft, 2019). This Declaration asserted that scholarly research results and cultural heritage shall be freely accessible and usable for scientists and the public. Fundamental to the declaration is that Open Access (OA) is a responsibility of research performing organisations and research funding organisations, and that the publication and dissemination of research results are integral parts of the research process. Following this declaration, several initiatives on Open Access and Open Science were carried out by various communities and nationals around the world. A brief description of some of the initiatives are described below.

### *2.1 The G8 Community* (G8 UK, 2013)

In June 2013, the G8 Science Ministers met in London approved of a statement which proposed the consideration of new areas for collaboration and agreement on global challenges, global research infrastructure, open scientific research data, and increasing access to the peer-reviewed, published results of scientific research. In order to address global challenges and maximise the social and economic

benefits of scientific research, the G8 Science Ministers support the set of principles for open scientific research data which included publicly funded scientific research data to be opened with fewest constraints as possible; open scientific research data should be easily discoverable, accessible, assessable, intelligible, useable, and interoperable to specific quality standards, where possible and to maximise the value that can be realised from the research data. To ensure that open scientific research data principles will be adopted by the scientific communities, the G8 Science Ministers agreed for need of an appropriate policy environment to underpin the Open Science initiative.

### 2.2 CODATA (CODATA, 2019)
CODATA is an interdisciplinary Committee on Data for Science and Technology of the International Science Council (ISC) established in 1996. Amongst its role is to promote global collaboration to advance Open Science and to improve the availability and usability of data for all areas of research. CODATA supports the principle that research data should be available and "open as possible and as closed as necessary". CODATA advocates for these data to follow the FAIR (Findable, Accessible, Interoperable and Reusable) principles. In its Prospectus of Strategy and Achievement 2016, CODATA has identified three priority areas in their Open Science initiative which are:
i)    to promote principles, policies and practices for Open Data and Open Science;
ii)   to advance the frontiers of data science;
iii)  to build capacity for Open Science needed to support open data.

### 2.3 Japan (Global Perspectives Cabinet Office Japan, 2015; Research Center for Open Science and Data Platform, 2019)
Japan Science and Technology Agency (JST) established an Open Access policy on research publication and research data management known as the JST Open Access Policy in 2013. The policy defines JST's stand on Open Access to research publications and management of research data resulting from research projects funded by JST and researchers who participate in projects awarded by JST are required to handle research results appropriately complying with this policy. This policy was recently replaced by the JST Open Science Policy.

### 2.4 Australia (Houghton et al., 2009; Mizera, 2013; Australasian Open Access Strategy Group, 2019)
In January 2013, the Australian Government enacted a policy on Open Access. Under this new policy, all the results of research conducted with the financial support of the Australian Research Council (ARC) must be published in an Open Access model within 12 months of publication and that these materials should be published in specific institutional repositories. As stated in the ARC's website:

> "The overarching aim of ARC's Policy is to ensure that the findings of publicly funded research are made available to the wider public as soon as possible. Both the research community and the public gain from knowledge derived from ARC funded research, and both wish to derive maximum benefit from these outputs."

### 2.5 China (Markin, 2018; Li and Zhang, 2019)
In May 2014, the Chinese Academy of Sciences published its Open Access policy calling for the free accessibility of publicly funded research results in the form of academic articles. In doing this,

researchers are encouraged to adopt the Green or Hybrid Open Access in the framework of which scientific papers enter Open Access 12 months after their publication.

In October 2017, China joined the global OA2020 initiative that aims to accelerate the transition to Open Access around the world. Leading scientific institutions of China, such as the Chinese Academy of Sciences (CAS), China's National Science Library and National Science and Technology Library, have affirmed the importance of Open Access for scientific research and communication.

In May 15, 2018, the National Natural Science Foundation of China (NNSFC), which supports basic science, and CAS, a body that provides research funding for over 100 scientific institutions in China issued a policy statement on Open Access, mandating that research results of the projects they fund should be made openly accessible within 12 months of their publication.

### 2.6 United States of America (National Institutes of Health, 2003; Nielsen, 2011; Noorden, 2013)

Since 2008, the US National Institutes of Health (NIH) has required research to be publicly accessible after 12 months. However, this new policy does not insist that every agency copies the NIH approach exactly. In 2012, John Holdren, the director of the White House office of science and technology policy (OSTP), told federal agencies to prepare plans to make their research results free to read within 12 months after publication following a petition urging the president to require free access to scientific journal articles from publicly funded research. In February 2013, the US government announced its Open Access policy which mandated all publications arising from taxpayer-funded research to be made free to read after a one-year embargo period.

### 2.7 European Commission Initiative (Ramjoué, 2015; European Commission, 2017; European Open Science Cloud, 2017; European Open Science Cloud, 2019)

The European Commission has taken a big step towards open science in Europe and is probably the most matured initiative. For the European Commission, open science provides the context for open access to publications and open research data. Since 2008, the European Commission has been running the Open Access Pilot in their FP7 programmes. Currently, all projects receiving Horizon 2020 funding are required to ensure that any peer-reviewed journal article they publish is openly accessible and free of charge. In 2016, European Commission went one step further by launching the European Open Science Cloud (EOSC). EOSC is an initiative to build a competitive data and knowledge economy in Europe. At the first EODC Summit in June 2017, the EOSC Declaration was endorsed by more than 70 institutions.

### 2.8 Singapore (Ooi, 2017; UNESCO, 2017)

Closer to home, Singapore contributes to the world of Open Access (OA) in the form of Institutional Repositories in some of the well-known Institutions in Singapore. As of May 2015, there are 3 OA repositories from Singapore registered in the Registry of Open Access Repositories (ROARMAP). They are "Institutional Knowledge" at Singapore Management University, "Scholar Bank" at National University of Singapore and "Digital Repository (DR-NTU)" at Nanyang Technological University. As of July 2014, the Singapore's National Research Foundation (NRF) requires research-performing institutions to have Open Access policies in order for researchers to access their grants.

*2.9 Malaysia* (Akademi Sains Malaysia, 2019)

Malaysia does not yet have an open science policy. However, recently, the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) and the Academy of Sciences Malaysia (ASM) launched the Malaysia Open Science Platform (MOSP) initiative. MOSP is to be a trusted data-sharing platform that enables accessibility and sharing of research data aligned with the national priorities and international best practices to strengthen science, technology and innovation (STI) collaborative ecosystem for Malaysia. The first phase of this initiative is aimed at connecting research data, researches and publication between five research universities, and 15 MESTECC research institutes and agencies.

## 3. Summary

Open science is a movement to make scientific research, data, and dissemination accessible to all levels of an inquiring society, amateur or professional. This includes open access to the outputs of scientific research, such as data and publications. It also provides opportunities for citizen science where the public can voluntarily participate voluntarily in the research process, thus enabling real-world problems to be addressed.

Open Science is about sharing knowledge as early as practically possible in the discovery process' which may lead to a boost in innovation. It does not, however, mean 'free science'. It is therefore essential to ensure that intellectual property is protected before making knowledge publicly available to others that would translate research output into innovation and new technologies.

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