Scientific Data: an open access and open data publication to facilitate reproducible research

Author information:

Iain Hrynaszkiewicz, Head of Data and HSS Publishing, Open Research, Nature Publishing Group & Palgrave Macmillan, The Macmillan Campus, 4 Crinan Street, London, N1 9XW

Yoko Shintani, Marketing Manager, Nature Publishing Group & Palgrave Macmillan, Chiyoda Building. 2-37 Ichigayatamachi Shinjuku-ku, Tokyo 162-0843

Abstract

As open access to journal articles has become more established in scholarly publishing, a number of Scientific Technical and Medical (STM) publishers are working to help provide open access to research data (open data). Researchers are generally supportive of data sharing and publication but they often lack incentives and mechanisms to share data effectively. For open data to help increase scientific reproducibility and reliability it must be more than just available – it should be understandable and reusable and, ideally, validated through peer review. Data journals and data articles have emerged as a new type of publication to help address these issues. Nature Publishing Group has developed a data journal in response to the needs of research funders and a survey of key stakeholders. The journal, *Scientific Data*, published its first articles in May 2014. The primary article type, the Data Descriptor, combines traditional scientific article content with structured machine-readable information, and has been devised to enable searching across different data types, linking of data to publications, and data-mining.

Keywords: open science, open access, open data, data journal, Scientific Data, reproduction, reuse, data sharing, repository, data curation

This article is a translated preprint. It was first published in Japanese in the journal *Johokanri - Journal of Information Processing and Management* under a Creative Commons attribution license (CC BY).

Attribution: Hrynaszkiewicz I & Shintani Y: *Johokanri - Journal of Information Processing and Management* Vol. 57 (2014) No. 9 P629-640 http://dx.doi.org/10.1241/johokanri.57.629

Main text

1. Introduction

As open access to journal articles has become more established in scholarly publishing, a number of Scientific Technical and Medical (STM) publishers are working to help provide open access to research data (open data). Researchers are generally supportive of data sharing and publication but they often lack incentives and mechanisms to share data effectively. For open data to help increase scientific reproducibility and reliability it must be more than just available – it should be understandable and reusable and, ideally, validated through peer review. Data journals and data articles [Note1] have emerged as a new type of publication to help address these issues.

In this article, we discuss the need and drive for data publishing and data journals and introduce *Scientific Data*, launched in 2014 by Nature Publishing Group.

2. Beyond open access

Much of the innovation in data publication has been built on online publishing innovation stimulated by open access publishing, which began commercially in 2000. Now, in 2014, the Directory of Open Access Journals (DOAJ; http://doaj.org/) has indexed its 10,000th journal and the Registry of Open Access Repositories Mandatory Archiving Policies (ROARMAP; http://roarmap.eprints.org/) includes more than 470 open access mandates. Open access journals, which provide unrestricted online access to peer-reviewed literature, are an established and sustainable part of the scholarly publishing ecosystem and continue to grow at a faster rate than subscription journals – particularly in Scientific Technical and Medical (STM) publishing[1].

As well as enabling access to the literature, open access publishing can also enable efficient reuse of the literature. This is because open access articles published in scholarly journals are frequently published under a license, such as a Creative Commons Attribution license (CC-BY), with liberal sharing and reuse permitted [Note 2]. However, to fully enable research results to be validated and reproduced, open access to papers is not enough. Research data, and other products of scientific research such as source code and protocols, must also be freely available[2].

While reproducible research and access to data is not a new concept – indeed, it is a tenet of science – publishers have become increasingly involved in enabling access to research data in the past decade. Most STM publishers seek to speed the advancement of science, and provide services to scientific communities and their funding agencies. All these stakeholders are requiring better access and links and citations to research data in recognition of the benefits to scientific progress[3]. Enhancing the published record with data visualizations, integration and other data-rich content is, also, important for readers of journals. This movement towards the publication of more reproducible research has helped incentivize the development of new editorial and publishing policies[4,5], new content types, enhancements to publishing platforms, and changes to content licenses[6].

Providing access to data in journals as supplementary information, or links to data in repositories from traditional articles is a step in the right direction. However, for data access to enable reproducible research, data must be properly discoverable, understandable, and validated through peer review. The UK's Royal Society, in their landmark 'Science as open enterprise' report, described data made available in a way that made it truly useful to future research as "intelligently open data"[7]. The drive to make data available in a reusable way, coupled with the need to incentivize scientists to publish their data has led to the rise of data journals. Data journals typically publish peer-reviewed descriptions of research datasets and these journals have been growing in number in the past five years.

3. The need for data journals

There are many benefits of sharing data, for individuals and organisations and society but there are a number of barriers (Table 1). Credit, through publications and attribution, is very important for individual scientists' career progression (as well as attribution and credit helping to determine the provenance and validity of research, and tracking of impact). But a lack, or perceived lack, of credit for data publication is commonly cited as a reason not to share data, along with concerns over inappropriate reuse[8]. Data journals help incentivize scientists to publish data, and help them meet the requirements of funding agencies and research institutions, by providing a citable publication linked to or published alongside their dataset(s).

Table 1: Benefits of and barriers to data sharing

Benefits of data sharing	Barriers to data sharing
• Reduction of error and fraud • Increased return on investment in research • Compliance with funder and journal mandates • Reduce duplication and bias • Reproduction/validation of research • Testing additional hypotheses • Use for teaching • Integration with other data sets • Increased citations	• Concerns over inappropriate reuse • Limited time/resources • Costs associated with data sharing • Human privacy concerns • Unclear ownership of data/authority to release data • Lack of academic incentives/recognition • Lack of repositories or lack of awareness of repositories • Protecting commercially sensitive information

Data producers are facing increasing pressure to make their data available as governments, including the Japanese government[9, 10], are introducing open data policies to aide innovation and growth. Funder and institution-wide data sharing polices have emerged[11] more recently than policies from specific fields of science. The genomics community is widely held has having led the way in data sharing, standardization and reuse in biology. The huge, collaborative effort required to sequence the first human genome could not have been achieved without public data access as many different labs needed to work together to achieve

this goal. Other areas of science could potentially see a greater return on investment in research through reuse and archiving of data. To help achieve this, funders must incentivize scientists to share and describe data, and develop metrics and mechanisms to measure the amount of data their funding generates and how it is being used.

Data repositories can be specialized for particular scientific domains or types of data, such as microarray data deposited to GEO, or for particular institutions, such as University of Edinburgh's DataShare (http://datashare.is.ed.ac.uk/) repository. There are also some general data repositories, such as figshare (http://figshare.com/) and Dryad (http://datadryad.org/), which are working with journals and publishers to link articles to a wide variety of data types, including numerical spreadsheet data, videos, text files, geographical location information, and images[note 3] . Data can also be the purpose and subject of a journal publication, as a data paper. These types of article can either be published in journals that accept a variety of article types or in data journals. Many major publishers including Elsevier, Springer, BioMed Central and Nature Publishing Group publish data journals (for a list of data journals see [12] and for a more comprehensive review of this emerging area of scholarly publishing see [13]).

While it is possible to meet some community and funder data sharing requirements by depositing data in repositories, data journals and articles generally provide additional services and benefits (Figure 1). These include improved discoverability of data, through indexing of articles in journal repositories (e.g. Scopus, PubMed); credit via a journal article; and increased reliability of the data, if the journal peer reviews the data. Data journals can also provide recommendations on data formatting and deposition. The data article allows publication of detailed contextual and methodological information, enabling independent validation and reproduction of data. In this regard use of data journals can significantly add to the record of version, as printed journals in particular, are often subject to limitations on the amount of text or supplementary data they can publish[14]. Data journals can also provide an outlet for unpublished datasets and experiments with no previous publication. And by partnering with repositories data journals can also improve the accessibility and integration of data with journal articles and enhance the experience for readers.

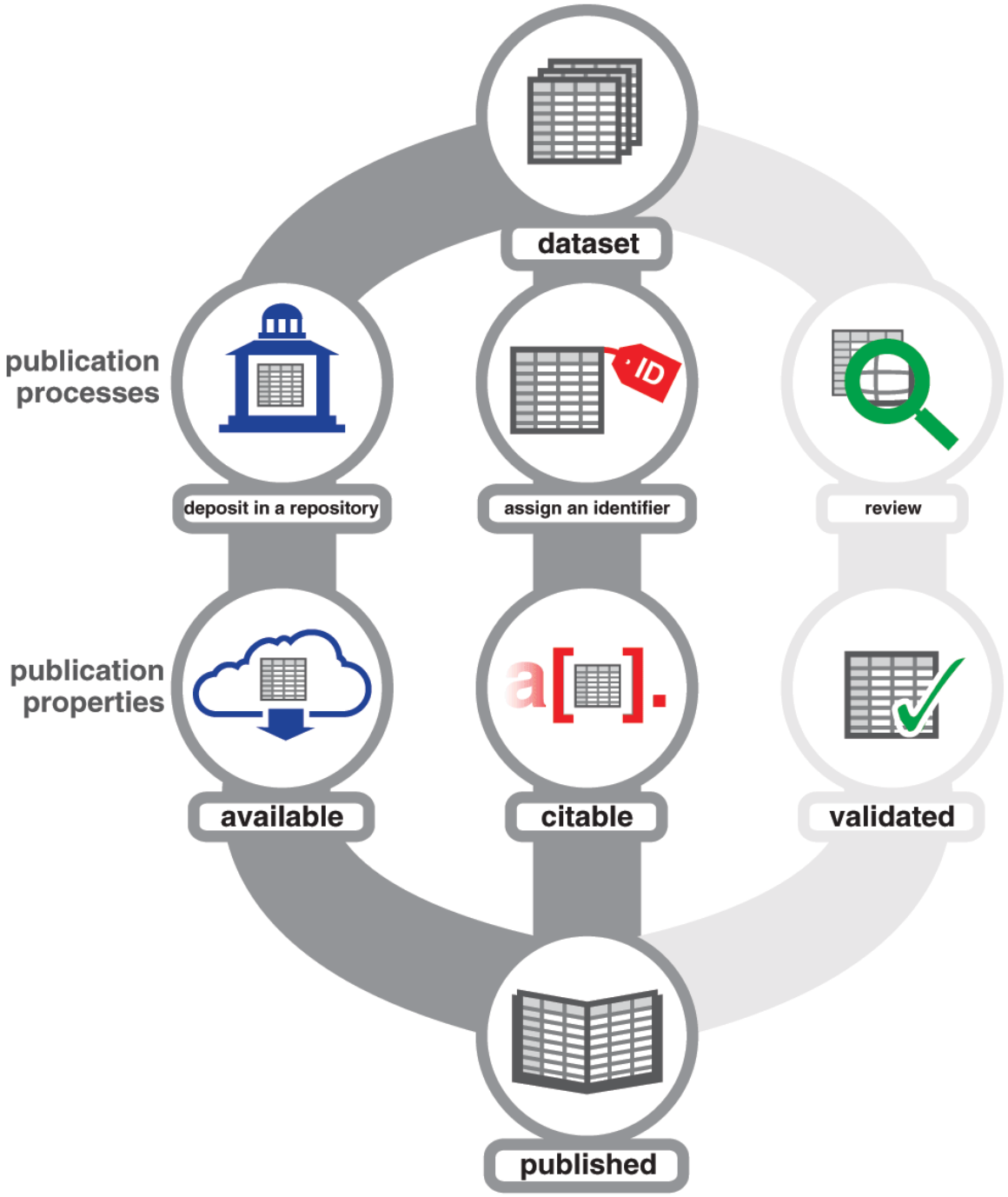

Figure 1: An overview of data publication

Original authors' title: '**To be published, datasets are typically deposited in a repository to make them available and assigned an identifier to make them citable**. Some, but not all, publishers review datasets to validate them.'

Image reproduced under the Creative Commons attribution license http://creativecommons.org/licenses/by/4.0/ from [13]

4. Introducing Nature Publishing Group's *Scientific Data*

Scientific Data is an open-access, peer-reviewed publication, from Nature Publishing Group, for descriptions of scientifically valuable datasets. The journal's primary article-type, the Data Descriptor, is designed to make data more discoverable, interpretable and reusable. Data Descriptors combine traditional scientific article content with structured information curated by the editorial team, and are devised to also enable searching across different data types, linking of data to publications, and data-mining[15].

The concept of *Scientific Data* was developed in response to a number of factors, in particular through a survey carried out by NPG that gathered quantitative and qualitative data from several stakeholder groups – researchers, funding agencies, librarians and data repository managers.

The survey, carried out in 2011, was completed by 387 respondents, 329 of whom were active researchers across the natural sciences. The aim was to gain an understanding of scientists' habits and attitudes to data preservation and sharing and test their reaction to the Data Descriptor concept. The results found a strong collaborative culture existed among the respondents, regardless of their primary area of interest, and many of them utilise other researchers' datasets and share datasets with colleagues. However, many respondents did not know of an appropriate public repository for their data. Also, the majority of respondents reacted positively to the concept of Data Descriptors and *Scientific Data* [16].

5. Key principles of *Scientific Data*'s model

While other journals had already begun publishing article types designed to describe datasets, either as data papers or data notes, there are some differences with *Scientific Data*'s approach (for the key principles behind *Scientific Data* see Box 1).

Box 1: Key principles of Scientific Data

1. Credit

- *Provides a citable, peer-reviewed mechanism for recording credit for dataset creation.*
- *Grants recognition for researchers who may not qualify for authorship on traditional articles.*
- *Builds a citation index for publicly available datasets, as well as any associated code and workflows.*

2. Reuse

- *Provides the information needed for interpretation, reuse and reproduction of data — including standardized and curated experimental metadata.*
- *Ensures linking to one or more trusted data resources, where data files, code or workflows are stored.*
- *Fulfils a significant part of funders' data-management requirements, particularly by demonstrating and promoting the reuse potential of research data.*
- *Uses and encourages open licences that allow for modifications and derivative works.*

3. Quality

- *Peer review focuses on evaluating the technical quality and completeness of Data Descriptors and associated datasets.*
- *Standards are ensured by an academic Editorial Board of recognized experts from a broad range of fields.*
- *Peer review is carried out by at least one scientist with experience in the relevant experimental techniques, and by one data-standards expert.*

4. Discovery

- *Content is uniformly searchable and discoverable.*
- *Validated links to related journal articles and data repository record are provided*
- *Accelerates integrative analyses by helping authors find relevant datasets across a wide range of different data-types.*

5. Open

- *Offers transparency in experimental methodology, observation and collection of data.*
- *Breaks down barriers to interdisciplinary research — facilitating understanding, connectivity and collaboration, which might not otherwise occur.*
- *Offers the most liberal Creative Commons license, CC-BY, as default for published articles and promotes open data-compliant legal tools for data – Creative Commons CCo.*

6. Service

- *Professional in-house data curation ensures standardized and uniformly discoverable content.*
- *Authors are able to deposit datasets at figshare or Dryad during submission*
- *Technology and experience of the Nature Publishing Group*
- *Fast peer review turnaround and rapid publication of Data Descriptors*

In comparison with other data journals, *Scientific Data* is unique in terms of its very broad scope, covering all life and physical sciences (and may expand further in the future). The journal is working with a wide range of data repositories and has accredited more than 60 (http://www.nature.com/sdata/data-policies/repositories) that meet its criteria for permanence and accessibility, broad community support, facilitation of confidential peer review and expert curation [17].

Perhaps the two most significant defining aspects of *Scientific Data* are its peer-review process, which includes in-house curation by a data curation editor, and the publication of structured, machine readable metadata files in the ISA-Tab format with every article[18]. These ISA-Tab metadata files have several potential applications, including enabling advanced users to search across and compare datasets from different types of data and scientific domain, as ISA-Tab can be used to describe the investigations (I), studies (S) and assays (A) used to produce the dataset(s), in a standardised way utilising predefined ontologies[19] (Figure 2). For non-technical users the ISA-Tab files can be seen, metaphorically, as "glue" that connects the data descriptors to the datasets they describe.

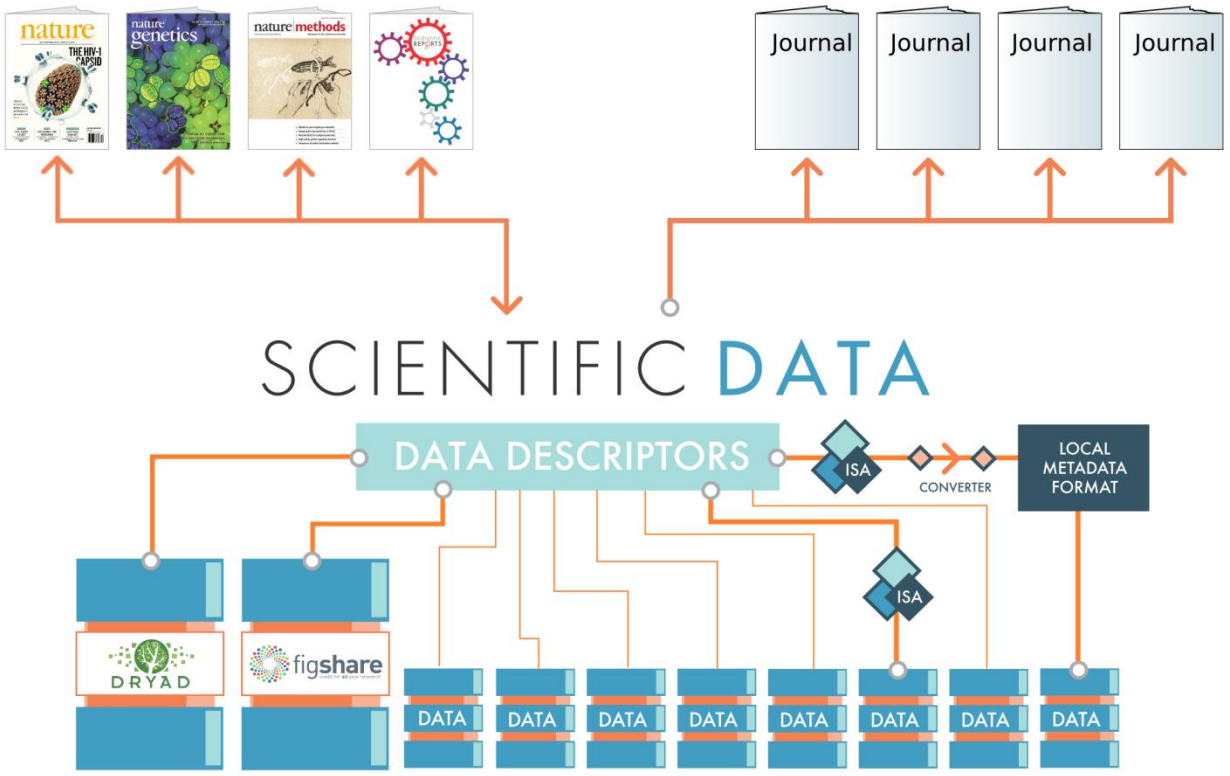

Figure 2: Where *Scientific Data* and ISA-Tab metadata fit in the data publication workflow

Figure 2 reproduced for this article with permission from Nature Publishing Group.

6. Anatomy of a Data Descriptor

Data Descriptors include detailed descriptions of the methods used to collect the data and describe technical analyses that support the quality of the measurements. Data descriptors do not contain tests of new scientific hypotheses, extensive analyses aimed at providing new scientific insights, or descriptions of fundamentally new scientific methods.

It is *Scientific Data*'s policy that all datasets central to a Data Descriptor must be submitted to an appropriate external repository, and that on publication, authors agree to make that data publicly available without restriction, except where reasonable controls related to human privacy or biosafety are needed. Data Descriptors are complementary to traditional research articles and may be used to describe datasets that are analyzed in other publications, or to describe standalone datasets. As of September 2014, more than two thirds of the published data descriptors in the journal described previously unpublished datasets.

The format of Data Descriptors was developed with feedback from the journal's Advisory and Editorial Board and through iteratively communicating key developments to, and seeking comments from, the wider community via the journal's blog. Several weeks ahead of the journal's formal launch, pre-launch articles were published [20]. The text of Data Descriptors includes, amongst others, sections for Methods, Technical Validation, Data Records, Usage Notes[21] – as these were determined to be essential for understanding, reusing, and reproducing datasets.

7. Data citations

As well as traditional References, Data Descriptors also include a list of Data Citations. This is in accordance with the Joint Declaration of Data Citation Principles[22] signed by multiple stakeholders in research publication, which state that, amongst other principles, that data citations should be accorded the same importance in the scholarly record as citations of other research objects including journal articles. Other NPG journals are working to implement data citations in the same way as *Scientific Data*. Data citations are an important part of data publishing. Data citations utilize an existing cultural and technical infrastructure in science and science publishing, where scientists give credit to one another's ideas through citation, and can legally attribute reuse or reproduction of work through attribution. Datasets are often assigned Digital Object Identifiers (DOIs) in a similar manner to journal articles, which enables tracking of citations through equivalent mechanisms to tracking journal article citations[23]. Thomson Reuters, who produce the Web of Science databases and Journal Impact Factor, have developed a Data Citation Index [Notes 4]. In addition, since 2009 the organisation DataCite has been working with various repositories and other scientific resources –including figshare – to assign DOIs to datasets, to facilitate data as a legitimate scholarly output. In August 2014 DataCite announced its cooperation with the Data Citation Index, which should facilitate further enhancements to data discoverability. [24]

As well as a list of data citations, *Scientific Data* includes a section for summarizing and providing links to each of the datasets described in the article in the main body of the article, in its Data Records section.

7. Peer review process

To be published in *Scientific Data*, the data described in the data descriptor must be scientifically valuable and have the potential for reuse – as judged by the peer review and editorial data curation process. The journal does not, however, consider perceived impact or importance as criteria for publication. Editors and referees review Data Descriptors according to four main criteria (see the guide to reviewers[25] for complete information):

1. Experimental rigour and technical quality (were the methods sound?)
2. Completeness (can others reproduce and reuse the data?)
3. Consistency (were community standards for reporting followed?)
4. Integrity (are the data in the best repository?)

While the journal welcomes Data Descriptors from studies – and linked to studies in journals judged to be – of high impact, the journal is a platform for a wide variety of data types regardless of the size or complexity of the data. Single experiment or single lab-generated datasets, such as [26] and [27] are considered in parallel with longitudinal datasets gathered over many years, such as the Duke Lemur Center's release in July 2014 of nearly 50 years of data on strepsirrhine primate taxa (Figure 3)[28]. This article has since been viewed more than 6,000 times (http://www.nature.com/articles/sdata201419/metrics accessed 10 September 2014).

Figure 3: **Obtaining strepsirrhine infant weights reproduced from Zehr et al.**

Image reproduced under the Creative Commons attribution license http://creativecommons.org/licenses/by/4.0/ from Zehr et al., Life history profiles for 27 strepsirrhine primate taxa generated using captive data from the Duke Lemur Center. *Scientific Data* 1, Article number: 140019 doi:10.1038/sdata.2014.19

A common question from scientists who are new to publishing data via a peer-reviewed journal independent from a traditional research article, is whether data publication would be considered a prior publication and so prevent them publishing their results and analysis in another journal. *Nature*-titled journals[29], along with many other journals and publishers, will not consider prior Data Descriptor publications to compromise the novelty of new manuscript submission as long as those manuscripts go substantially beyond a descriptive analysis of the data, and report important new scientific findings appropriate for the journal.

9. The status and future of *Scientific Data*

As of September 2014 *Scientific Data* had published nearly 30 Data Descriptors across a wide variety of life and physical science domains, including an article collection focusing on open data for evolutionary synthesis[30].

Published Data Descriptors have:

- built on previous publications in *Nature* journals[31]
- released new datasets, and source code, with these data visualized in figshare[32]
- provided formal publication of data gathered over decades but previously unreleased[33].

One of the articles included in the launch edition of the journal, presenting a comprehensive dataset of microRNA profiles in rats, was prepared by Japanese researchers Uehara *et al.* [34] and been viewed nearly 4,000 times (20th September 2014).

The journal operates an article processing charge (APC) model, as is established on many open access journals, as the costs associated with publication are not recouped through subscription charges. In 2014 an APC of ¥104,000 is levied for accepted articles. This is a fixed, one-off charge regardless of article length or number of figures, tables, datasets or authors' choice of Creative Commons licence type.

The future success of *Scientific Data* should be judged by the degree to which it enriches the scientific literature: by publishing valuable datasets that might not normally get into the open; by setting the standard for high quality data publishing; and by increasing the discoverability and reusability of datasets. The journal will focus on expanding the volume of articles and subjects it covers within life and physical sciences, and is investigating expanding into other areas in response to feedback from authors – such as social sciences and clinical medicine.

It should be recognised that open, reproducible research data are the means rather than the end – a means to conduct and communicate better science. To this end, it is our hope that *Scientific Data* will become an important part of the scientific publishing ecosystem, enabling academics to make their research data more discoverable, reusable, citable, and reproducible.

Notes

[Note 1]

Data papers or data articles are a new type of article. Scientific Data call the data papers it publishes 'Data Descriptors'.

[Note 2]

Under CC-BY, authors can copy and redistribute the material in any medium or format and remix, transform, and build upon the material for any purpose, even commercially. http://creativecommons.org/licenses/by/4.0/

[Note 3]

Scientific Data does not host research data; however, we work with a range of community-recognized repositories designed for specific data-types, model organisms or phenotypes, as well as the general-science repositories fig**share** and the Dryad Digital Repository.

[Note 4]

Data Citation Index. http://wokinfo.com/products_tools/multidisciplinary/dci/

References

1. Outsell: Open Access: Market Size, Share, Forecast, and Trends, Report: 2013
2. Laine C *et al*. Reproducible Research: Moving toward Research the Public Can Really Trust. *Annals of Internal Medicine* **146**, 450–453 (2007).
3. Hrynaszkiewicz I. The need and drive for open data in biomedical publishing. *Serials* **24**(1), March 2011
4. Bloom T, Ganley E, Winker M (2014) Data Access for the Open Access Literature: PLOS's Data Policy. PLoS Biol **12**(2): e1001797. doi:10.1371/journal.pbio.1001797
5. Announcement: Reducing our irreproducibility. *Nature* **496**, 398 (25 April 2013) doi:10.1038/496398a
6. Hrynaszkiewicz I, Busch S, Cockerill MC. Licensing the future: report on BioMed Central's public consultation on open data in peer-reviewed journals. *BMC Research Notes* 2013, **6**:318 doi:10.1186/1756-0500-6-318
7. Science as an open enterprise (Royal Society, 2012) https://royalsociety.org/~/media/policy/projects/sape/2012-06-20-saoe.pdf
8. Rathi, V. *et al.* Clinical trial data sharing among trialists: a cross-sectional survey. *BMJ* **345**, e7570 (2012)
9. Takagi S. Member blog: Japan's growing open data movement http://theodi.org/blog/japan-open-data (accessed 10th September 2014)

10. Ohmukai I. Progress and challenge of open data in Japan. *Journal of Information Processing and Management*. Vol. **56** (2013) No. 7 P 440-447
11. EPSRC policy framework on research data (accessed September 10th 2014) http://www.epsrc.ac.uk/about/standards/researchdata
12. Callaghan S. A list of Data Journals (in no particular order) http://proj.badc.rl.ac.uk/preparde/blog/DataJournalsList
13. Kratz J and Strasser C. Data publication consensus and controversies [v2; ref status: indexed, http://f1000r.es/3hi] *F1000Research* 2014, **3**:94 (doi: 10.12688/f1000research.3979.2)
14. Welcome, *Scientific Data*! *Nature* **509,** 534 (29 May 2014) doi:10.1038/509534a
15. More bang for your byte *Scientific Data* **1,** Article number: 140010 doi:10.1038/sdata.2014.10
16. Nature Publishing Group (2014): Data publication survey - raw data. figshare. http://dx.doi.org/10.6084/ m9.figshare.1234052, (accessed 2014-11-10)
17. What are *Scientific Data*'s data-repository selection criteria? http://www.nature.com/sdata/about/faq#q21 (accessed 10th September 2014)
18. Hufton A. *Scientific Data*'s metadata specification http://blogs.nature.com/scientificdata/?p=755 (accessed 10th September 2014)
19. Sansone *et al.*, Toward interoperable bioscience data. *Nature Genetics* **44,** 121–126 (2012) doi:10.1038/ng.1054
20. Hufton A. *Scientific Data*'s first publications http://blogs.nature.com/scientificdata/2014/03/24/scientific-data-releases-two-pre-launch-data-descriptors (accessed 10th September 2014)
21. *Scientific Data* submission guidelines http://www.nature.com/sdata/for-authors/submission-guidelines (accessed 10th September 2014)
22. Joint Declaration of Data Citation Principles – FINAL https://www.force11.org/datacitation (accessed 10th September 2014)
23. Edmunds, SC *et al.*, Adventures in data citation: sorghum genome data exemplifies the new gold standard. *BMC Research Notes* **5,** 223 (2012).
24. Japanese news blog on collaboration between Thomson Reuters and Data Cite. http://johokanri.jp/stiupdates/info/2014/08/010299.html, (accessed 2014-09-10).
25. *Scientific Data* guide to referees http://www.nature.com/sdata/for-referees#writing-review (accessed 10th September 2014)
26. Di Stefano *et al.* Time-resolved gene expression profiling during reprogramming of C/EBPα-pulsed B cells into iPS cells. *Scientific Data* **1,** Article number: 140008 doi:10.1038/sdata.2014.8
27. Hanke *et al.* A high-resolution 7-Tesla fMRI dataset from complex natural stimulation with an audio movie. *Scientific Data* **1,** Article number: 140003 doi:10.1038/sdata.2014.3

28. Zehr *et al.*, Life history profiles for 27 strepsirrhine primate taxa generated using captive data from the Duke Lemur Center. *Scientific Data* **1,** doi:10.1038/sdata.2014.19
29. *Scientific Data* Frequently Asked Questions: If I publish a Data Descriptor describing a dataset and a research article based on analysis of that dataset, does that count as dual publication? http://www.nature.com/sdata/about/faq#q17 (accessed 10th September 2014)
30. Vision TJ & Cranston K. Open data for evolutionary synthesis: an introduction to the NESCent collection. *Scientific Data* **1,** Article number: 140030 doi:10.1038/sdata.2014.30
31. Hao *et al*. Global integrated drought monitoring and prediction system. *Scientific Data* 1, doi:10.1038/sdata.2014.1
32. Plooij *et al*. Longitudinal recordings of the vocalizations of immature Gombe chimpanzees for developmental studies. *Scientific Data* **1,** Article number: 140025 doi:10.1038/sdata.2014.25
33. Uehara *et al*. miRNA expression atlas in male rat. *Scientific Data* **1,** doi:10.1038/sdata.2014.5

Bibliography (not included in above references)

a) Christopher Lortie, The citation revolution will not be televised: the end of papers and the rise of data. http://blogs.lse.ac.uk/impactofsocialsciences/2014/09/05/citation-revolution-end-of-papers-rise-of-data/, (accessed 2014-09-10).

b) HOW OPEN IS IT? Open Access Spectrum (OAS). http://www.plos.org/open-access/howopenisit/, (accessed 2014-09-10).

c) Tenopir, C; Allard, S; Douglass, K; Aydinoglu, A. U.; Wu L. et al. (2011) Data Sharing by Scientists: Practices and Perceptions. PLOS ONE. 2011, vol. 6, no. 6: e21101. http://dx.doi.org/10.1371/journal.pone.0021101, (accessed 2014-09-10).

d) Nobuko MIYAIRI. Open science and scientific data *Journal of Information Processing and Management*. Vol. **57** (2014) No. 2 P 80-89.

e) Sho SATO. Growth of the open access movement and current issues *Journal of Information Processing and Management*. Vol. **56** (2013) No. 7 P414-424.

f) Soichiro TAKAGI Development of open data policy in Europe *Journal of Information Processing and Management*. Vol. **55** (2012) No.10 P746-753

g) 林和弘. 新しい局面を迎えたオープンアクセスと日本のオープンアクセス義務化に向けて. 科学技術動向研究. 2014, no. 142, p. 25-31. http://data.nistep.go.jp/dspace/handle/11035/2471

h) 倉田敬子. OpenAccessはどこまで進んだのか（2）オープンアクセスはいかに実現されてきたのか. SPARC Japan NewsLetter. 2012, no. 14, p. 5-8. http://www.nii.ac.jp/sparc/publications/newsletter/pdfper/14/sj-NewsLetter-14-3.pdf