Promoting Open Science in Japan

—Opening up a new era for the advancement of science—

March 30, 2015

The Expert Panel on Open Science, based on Global Perspectives

Cabinet office, Government of Japan

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Executive Summary

It is vital for Japan to participate in international discussions and to demonstrate a proactive approach to the promotion of open science. The Expert Panel on Open Science based on Global Perspectives has discussed various relevant issues of immediate importance for Japan. Based on these discussions, the Panel presented the guiding principles for promotion of open science in Japan.

I. The Importance of Open Science

"Open science" refers to a new approach to promoting innovation through knowledge creation in science and technology. This will be realized by facilitating access to and use of publicly funded research results such as scientific papers and their underlying data by the scientific community, industry and the general public.

The concept of open science is spreading rapidly. At the G8 Summit held in June 2013, G8 Science Ministers issued a joint statement that endorsed the need for increasing access to publicly funded research, including peer-reviewed published research and research data. The statement triggered discussions in various forums worldwide.

Meanwhile, Japan has not formulated its position on open science and has to date held very few officially organized discussions on research data.

Consequently, Japan may be unprepared for international discussions on the future framework of open science. In addition, in the absence of guiding principles, the international visibility of Japan's science and technology may be weakened, which may lead to the loss of opportunities for Japanese researchers in the global Research community, and to the decline of Japan's international competitiveness.

Japan should keep pace with the global advancement of open science in a collaborative yet also strategic manner, so that the value of Japan's latest research and development activities can lead to business activities at the next stage.

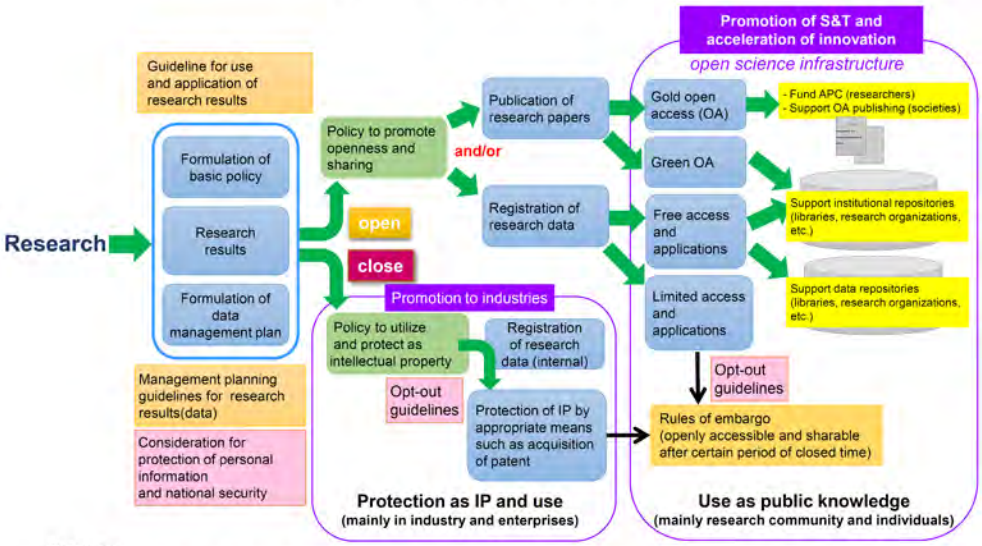
II. The Need to Promote Open Science

Open science may change scientific research. It will not replace traditional research methods, but will add new tools that help to advance science. It will make research results widely available in digital formats to all users including the scientific community, industry and the general public. This will enable additional value to be extracted from science and technology information, which will not only improve our knowledge, but will also reform innovation strategies.

For the scientific community, the acceleration of data-driven activities is expected to lead to new collaborations and to the prevalence of new research methods among researchers within the same research discipline and beyond. Industry and individuals are also expected to gain as they develop new products and services as a result of better use of scientific result data.

Japan is a country that is poor in natural resources. Therefore, to continue its sustainable development, it is vital to keep creating new values by combining science, technology and innovation. Open science provides a framework for this combination, which is why it is necessary to form a shared view on open science among stakeholders.

Promotion of Open Science



Reference:
Guidelines on Open Access to Scientific Publications and Research Data in Horizon 2020 Version 1.0 11 December 2013 p.4
http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-pilot-guide_en.pdf

III. Response to the Global Trend in Open Science

1. Guiding principles of the Japanese Government

The core principle of promoting open science in Japan is to enhance the utility of publicly funded research, including research papers and research data.

Stakeholders such as relevant ministries, funding agencies, universities and research institutions should be responsible for the implementation of open science, and for the formulation of implementation plans and policies. For their reference, common items and points of attention are listed below.

The Cabinet Office and the Council for Science, Technology and Innovation will coordinate the promotion of open science within the government and follow the progress of each stakeholder.

2. Basic View regarding the Promotion of Open Science

(1) *Objective and Significance of Promoting Open Science*

The results of publicly funded research contain new discoveries and insights that help advancing areas such as health, energy, environment and agriculture. Improving access to these results will make them better known and understood, and will consequently lead to the generation of new discoveries, research concepts, industries, as well as reinforcing competitiveness, promoting global-scale research, and boosting economic growth.

(2) *Scope*

The outcomes of publicly funded research, such as published results and underlying data, should be accessible, unless they interfere with personal privacy, national security or direct commercial interests.

(3) *Definition of "Publicly funded" and Scope of Research Data*

"Publicly funded" refers to research funding raised by the government or via an open call.

"Research data" includes meta data, numerical data, text records, images and visual data.

(4) *Responsibilities of Institutions Engaging in Research*

Each respective institution must formulate regulations on the management of research results.

In particular, they must prevent damage to or disappearance of research results.

3. Implementing Policies at Relevant Institutions

(1) *General Principles*

Plans and Policies on open science must contain the following elements:

- a plan for reinforcing innovation and competitiveness
- a transparent process for stakeholders
- a method for locating and accessing digital data resulting from publicly funded research
- an approach for optimizing search, archival and dissemination of information
- a plan for notifying publicly funded researchers of their obligations (new guidelines, revision of relevant regulations, etc.)
- a strategy for evaluating and enforcing compliance with the plan
- procurement of resources within the existing agency budget to implement the plan
- the formulation of roadmaps for implementing the plans
- a plan for developing data infrastructure such as repositories

(2) *Access to Scientific Papers*

Open access should be promoted in accordance with the Budapest Open Access Initiative of 2002.

Scientific results arising from publicly funded research should be stored for long-term preservation and accessible by any users for search, retrieval and analysis.

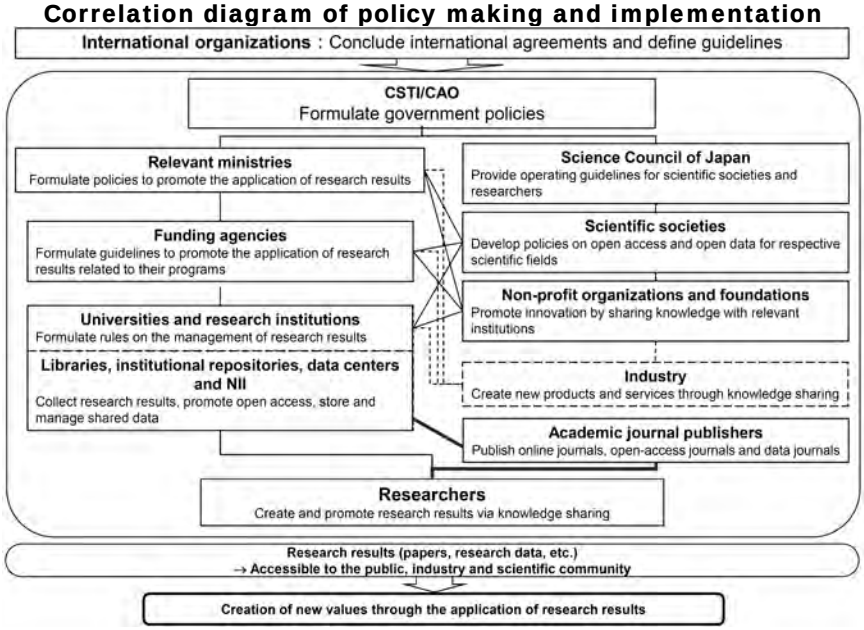
(3) *Access to Digitized Research Data*

Different scientific disciplines have varying methods of preserving and sharing research data. This should be considered when providing public access to digitized outcomes of publicly funded research.

(4) *Implementation of Open Science Plans*

Each respective institution should publicize its open science plans by posting them on its website. This activity will be monitored by the Cabinet Office and the Council for Science, Technology and Innovation.

Correlation diagram of policy making and implementation



Introduction

Open science is a concept that includes the notions of *open access* and *open data*; the items to be made open include results, data, and new knowledge findings from research activities, and the concept as a whole is interpreted in connection to creation of innovation.

With regard to the accomplishments and data that serve as wellsprings for new innovations, in recent years, many foreign nations—aided by information and communication technologies (ICTs) that enable rapid digitization and sophisticated networking—have begun to extend the availability of science beyond the traditional audience of researchers to a wider range of participants. In particular, the movement toward open science, which encourages the sharing and collaborative utilization of the results of research supported by public research funds, has been especially prominent.

Generally speaking, science consists of the discovery of objective principles and laws governing natural phenomena, and it is only through repeatedly systematizing and offering open explanations of these principles that the field can advance. One particularly dramatic advance in the establishment of the open science paradigm was the 15th century communication revolution made possible by the printing press. By enabling the production of large quantities of printed material, the printing press made possible the efficient recording and communication of research processes and methods; this led to the formation of a scientific community and the gradual accumulation of carefully selected wisdom and information. In the 17th century, the Royal Society of London began publishing its *Philosophical Transactions*, which enabled the rapid announcement of research results and sharing of data. In the 19th century and the years that followed, the increasingly fine-grained specialization of science ensured that the field became deeper as it developed. Some have begun to point out that science today is facing an era of transition in terms of both quantity and methodology, and that the resources, including research funding, that society as a whole can allocate to science are nearing their limits. Moreover, the development and spread of ICTs, in contrast to paper media, have made it possible to accumulate large quantities of information, which can be searched and retrieved instantaneously via the Internet. By incorporating analytical tools, the nature of research methods has undergone dramatic change. These developments have brought about an epochal transformation in the pathways to scientific discovery, and methods for erecting knowledge continue to expand and diversify. The traditional notion of the *journal paper* as the primary means by which research results are communicated, a tradition which began in the 17th century and endured for over 300 years, is also undergoing transition. Changes in scientific methods and the environment surrounding science have begun to change the very framework of scientific research activities, ushering in an era of worldwide revolution in scientific communication. It is within this period of transitional foment, bridging the pre-network practice of science with the future practice of science in an open and networked world, that the concept of *open science* has arisen as a process for the creation of new knowledge.

Within this open science paradigm, we can look forward to the efficient production of new value that follows from exploiting, in ways that transcend boundaries between both scientific fields and nations, results and data from research that has newly been made open thanks to the rapid development of ICTs. Moreover, by increasing access to the results of research (including publications and data sets), we can look forward not only to ripple effects throughout the scientific research system, but also, more broadly, to a stronger innovation system permeating society as a whole.

The increasingly widespread nature of the notion of *open science*—an idea which might truly be said to represent a paradigm shift in the sciences—has already exerted significant impact on the international discussion surrounding the question of the openness of the scientific enterprise. In particular, at the meeting of G8 science ministers convened in the U.K. in June 2013, a joint statement

called not only for the transition of scientific papers to an open-access format, but also for a transition to the open availability of research data, an event which only accelerated the pace of global discussion. In particular, the pace of discussion surrounding the open availability of research data has accelerated in multiple ways: in some foreign countries, agencies responsible for the distribution of research funds have begun clamoring for the results of research conducted with public funds to be made publicly available, while large numbers of researchers from nations around the world now participate in international forums for discussing issues related to open access and open data.

However, to date, Japan has never had a unified, clearly articulated perspective toward open science. In particular, there has been almost no organized debate in Japan regarding research data.

With discussions of scientific openness proceeding apace worldwide, Japan must become a world leader in developing strategies, even within collaborations that enable the new value being created by research activities in Japan to be connected to the next stage of enterprise activities. If the present situation continues with no clear activity or demonstration of intent from Japan, then Japan runs the risk of missing an opportunity to participate in the debate, perhaps resulting in the establishment of de facto international standards within which Japan's only role is to be a unilateral provider of data. In that case, the transition to an open world may simply proceed around us, with no consideration of Japan's particular situation. Taking this to its logical conclusion, if, within the establishment of international partnerships, there is no progress toward the sharing of data that truly needs to be shared, Japan may be excluded from participation in the types of research that are promoted on a global scale. Japan's international competitiveness will then plummet, and accordingly, global recognition of Japanese science and technology will fall. This is a bleak prospect that should concern us all.

For these reasons, it is essential that several steps be taken. First, personnel involved in science and technology policy must establish a common, shared sensibility, based on a global outlook, for distinguishing the types of research data that should be made open from those that should not. Then, based on the unique characteristics of various fields of research, we must further the status of fruitful discussions within Japan, organize Japan's basic posture and basic policies, participate in the circle of international debates, and make Japan's presence known. In this spirit, the present report summarizes the results of work by the Committee to Investigate Open Science Based on International Trends to investigate the initiatives that Japan should immediately move to implement.

I. The Importance of Open Science

1. The global expansion of open science

Open science is a new paradigm for the advancement of science. This paradigm calls for the results (including publications and research data) of any research conducted using public funds to be made easily accessible to, and available for use by, not only the full scientific community but also the industrial world and society at large. In addition to blazing new trails toward the creation of new knowledge, the paradigm aspires to effectively achieve methods for promoting science and technology research that lead to the creation of innovation. In recent years, the notion of open science has begun to spread rapidly around the world.

Open science is an approach to modern science borne by marrying the traditional notion of openness, namely, the open availability of publications, to the myriad ICT tools that have revolutionized society as a whole. The concept is important for any policymaker seeking to promote long-term research and innovation in science and technology.

The notion of open science has the potential to enact a major transformation in the long-standing habitual way of thinking, which holds that research is based on the individual brainstorms of individual researchers, and, while its results are to be made public in the form of journal papers, the actual data underlying the journal papers are the intellectual property of the researcher, who owns it.

An additional possibility brought forth by the spread of open science is the notion that citizen science is important and must be recognized. Although this report will not address this topic in detail, the open flow of information encourages the citizenry to participate in scientific research; this not only improves scientific literacy among the Japanese population, but also gives rise to new research methods and new discoveries made possible by the participation of large numbers of citizens; this point deserves careful attention.

2. International movements toward greater openness

Organizations such as the G8, the Organisation for Economic Co-operation and Development (OECD), the Global Research Council (GRC), and others have argued that publications and other results of publicly funded research should, by default, be public, and that data should be open as well, within feasible limits.

We must take steps to respond to these developments. For example, we should increase the number of exemplary situations that can serve as models to demonstrate the benefits of open access. At the same time, paying due heed to international competition, we should take pains to distinguish such cases from situations in which public availability can have harmful repercussions.

3. The evolution of research styles in the era of open science

Inspired by the cultures of globalization and information sharing and enabled by the astonishing progress of ICTs, open science is a new wave of thinking that is now seeping into the scientific world. This will inevitably bring about changes to traditional systems and styles for conducting research.

In traditional research, the production of knowledge proceeded in accordance with a system of finely specialized disciplines. The attributes of research that were emphasized and evaluated included

contributions to the systematization of knowledge within disciplines, academic sophistication, and originality. A style of research with the following key pillars was developed and entrenched: (1) the establishment of priority (announcement of research results); (2) the consolidation of science; (3) validation by third parties (peer review); and (4) the responsibility of the author to explain the work.

In contrast, modern science has experienced significant changes—spurred by the development and spread of ICTs, and accelerated by the progress of the Internet—to both the style and content of research. Huge quantities of condensed data form the basis of scientific experiments and research, and the Internet has driven the appearance of a new approach to the production of knowledge in which "research data" is applied and reused in ways that transcend boundaries between specialized fields. We have witnessed a paradigm shift from old-fashioned notions of open access—typified by the *disclosure and communication of results* via journal papers—to a new world that emphasizes the opening-up of the research process itself, including *open access to research data and other results*. The creation of knowledge has accelerated in a way that transcends barriers between both individual researchers and specialized fields, and new styles of collaborative research and research methods are taking shape. As a result, we can look forward to the birth of new research paradigms and new intellectual discoveries that would have been unimaginable within the research style of the past. Moreover, as the research process is rendered increasingly transparent, we can anticipate new sources of research funding made possible by greater understanding and broader scientific awareness among society as a whole.

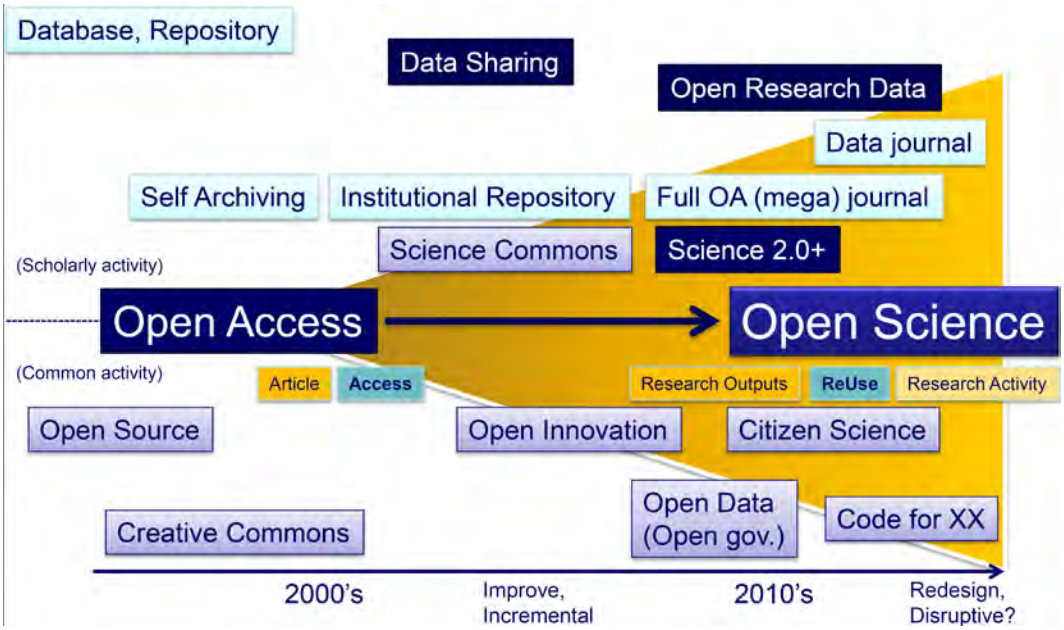


Figure: The evolution from open access to open science

4. The core structural elements of open science

(A) Open Access

In this section, we offer a brief description of the two key ingredients that play a central role in promoting open science: *open access* and *open data*. We discuss the fundamentals of these two philosophies and survey the present status of their adoption around the world.

(i) The basic notion of open access

One definition of open access is that given by the Budapest Open Access Initiative (BOAI) in April 2002: "By 'open access' to peer-reviewed research literature , we mean its free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself."

Some background behind the origins of the open access movement

(a) The serials crisis

The *serials crisis* refers to the inexorable rise in the cost of academic journals, due to a complex interplay among various factors, that has made it difficult for university libraries and other research institutions to continue to allocate the resources necessary for journal subscriptions, denying researchers the freedom to publish their results and access those of others. Factors contributing to the serials crisis include: (1) the global increase in the number of journal articles; (2) the peculiarities of a marketplace in which there is often only one provider for a given need, ensuring the absence of competition; (3) the fact that the publication of academic journals—the forum in which researchers present their research—depends on the commercial publishing industry; and (4) the fact that the consumers (researchers) and purchasers (libraries and similar institutions) are two different sets of people, giving rise to a moral hazard in which users who do not directly bear the burden of costs create a usage environment characterized by excessive demand. One particularly prominent illustration of the crisis posed by this situation is furnished by a 2012 report prepared by the steering committee of the Harvard University Libraries. Harvard University was concerned by the fact that subscription fees for online journals from two publishing companies rose 145% between the years 2006 and 2012; the report proposed that the best policy for defusing the serials crisis was to switch to online open-access journals.

The serials crisis has also provoked a response from Japan in the establishment of JUSTICE (the Japan Alliance of University Library Consortia for E-Resources), an organization whose goal is to ensure the stable ongoing provision of and access to electronic journals and other academic information for Japanese universities. Other movements in this direction include "An Urgent Appeal for a Reorganization of the Access Environment for Electronic Journals," a set of three proposals issued by the Bussei Group (Material Properties Group), an organization in the field of material physics, that include a call for the establishment of new information access systems.

(b) Advances in the digital environment and the increasing range of information transmission

Thanks to the development of the Internet and the resulting transition to electronic formats for academic journals, the threshold cost for communicating scientific and technological information is falling ever closer to zero, creating an environment in which the results of research can be readily shared with the entire world. Cases in which researchers distribute articles through their own personal websites have also begun to increase.

(ii) Expanding conceptions of open access: From journal articles to data and other research results

Open access has developed into a set of ideas that extend far beyond the background issues that motivated the original discussion. A vast expansion in the opportunity to access research concepts spanning a broad range of disciplines has stimulated efforts to find common ground between disparate fields of research, thus ushering in an increasing diversity of scientific research; these

developments are widely anticipated to spur the creation new innovations and new industries based on the results of publicly funded basic research. Thus, the growth of the open-access paradigm has proceeded in tandem with the development of ICTs, enabling access to the results of research not only in the form of electronic journal articles, but also in actual data. As we witness the formation of a shared intellectual platform on a global scale, we can look forward to developments in research and the creation of innovations that would have been simply unimaginable in a previous era.

(B) Open Data

(i) The transition to open availability of administrative data and research data

In the past, activities related to open data were frequently interpreted as public disclosures of administrative data and other data possessed by governments. In this report, we consider a topic that is separate from the openness of administrative data, namely, the openness of research data. In contrast to the former subject, which is sometimes known as *open government,* the openness of research data is an area involving judgments to be made by researchers, experts, and the scientific community regarding questions such as the benefit and harm to scientific research activity and certain decisions regarding the handling and fine points of data relating to research applications. Thus, in establishing Japan's basic policies, we must conduct our investigations with a clear understanding of the differences between the openness of research and government data.

(ii) 5 principles for an open data infrastructure

These principles were agreed upon by the Group of Senior Officials positioned within the G8.

(a) Discoverable

All required data (or data sets) should be easy to find with the most widely used search methods of the day.

Specific technical steps include:

- Implementation of appropriate persistent identifier frameworks
- Adoption of descriptive metadata standards
- Appropriate data formats
- Data taxonomies
- Metadata searching and expert APIs (application programming interfaces)

(b) Accessible

Research data should be made openly available, subject to constraints that ensure ethical, legal, and commercial protections. Users of accessible data are obligated to clarify the source of the data in the same way that citations from articles or other sources would be acknowledged. These citations record the contributions of research data. Users of data may be required to agree to terms of use or licenses associated with particular data. Examples include consideration of the protection of privacy of human subjects, preservation of intellectual property, or agreement to an embargo approach. In addition, as citations for research data, preparations must be made to specify landing pages and data identifiers; these must follow international standard specifications such as those that apply to Digital Object Identifiers (DOIs).

(c) Understandable

A set of numbers, texts, pictures or even videos alone cannot be understandable without additional context, semantics, data analysis tools, and algorithms. Observational and experimental data must be accompanied by metadata specifying the conditions under which the data was generated (time,

location, observational equipment, experimental procedure). With regard to data quality, a set of rules must be established to ensure the integrity and provenance of the data throughout the entire process, from the creation of the data to its public release. These rules should be broadly recognized within the field of research appropriate for the data in question.

(d) Manageable
In order for research data to be managed in an efficient and effective manner, data management policies and plans must exist for all data at both project and institutional levels. Making research data available in a form that can be effectively used by others requires considerable and continued efforts over and above those that are necessary to undertake the primary research itself. Data management policies and plans must make clear who is responsible for maintaining the availability of data and how the associated costs are to be met; these policies must also address issues associated with curation, storage, and services. Plans and processes that consider the full range of potential uses for the data in a cross-disciplinary context must also be in place, and data with acknowledged long-term value must be preserved and remain usable for future research.

(e) People
A global approach to research data infrastructure such as that described above requires a highly skilled and adaptable workforce and organizational culture that is able to capture the available data and make it available to those that are able to use it appropriately. Specialized data custodians who can work across complex data sets and with diverse data protocols are also needed, as are changes in the culture of research data management within the research community.

Source: White Paper: 5 Principles for an Open Data Infrastructure Draft v2.0, 21 May 2013: G8 Global Data Infrastructure WG

(iii) The significance and objective of electronic administration of open data
The significance and objectives of electronic administration of open data in Japan are as follows.

- Improved transparency and reliability

When public data are provided in a form suitable for secondary use, the Japanese population, either independently or through private-sector services, will be sufficiently well informed to allow analysis and decision-making regarding government policy and other matters. This will increase the transparency of and enhance the trust in government among the population.

- Progress in citizen engagement and cooperation between the public and private sectors

As the utilization of public data via wide-area channels develops, data sharing between the public and private sectors will increase. This will promote public-private cooperation to provide public services, as well as the creation of new private-sector services using the information provided by the government. As a result, we will see the rapid and efficient provision of a wide variety of public services utilizing creative innovations. This will allow an optimal response to a variety of challenging circumstances facing Japan, including difficult economic circumstances, the diversification of values and needs in a variety of areas, and the increasing sophistication of information and communication technologies.

- Stimulating economic activity and administrative efficiency

The provision of public data in a form suitable for secondary use will stimulate the creation of a variety of new businesses, and make corporate activity more efficient, at various stages in the marketplace, including the compilation, processing, and analysis of data; this will stimulate Japan's

economy as a whole. Moreover, when national and regional governments use public data to conduct analyses of policy decisions, more efficient and sophisticated administration can be expected.

Source: e-Government Open Data Strategy (Ratified on July 4, 2012, by the Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society)

Criteria for using the term "Open Data"

1) Data exist in formats appropriate for machine reading
2) Data released in accordance with usage rules allowing secondary use

The Five Stages of Open Data (Source: XX) and Data Formats

Stage	State of public availability	Example data formats	Reference: Linked Open Data 5star
1	Data released from the source of the open license	PDF, JPG	OL -- Open License (accessible by computer; readable)
2	Stage 1 + release of data that may be processed by computers	XLS, DOC	RE -- Readable (Human and Machine) (Data may be edited by a computer)
3	Stage 2 + release of data allowing open use	XML, CSV	OF -- Open Format (application-independent format)
4	Release of data in web-standard formats (such as RDF)	RDF, XML	URI -- Universal Resource Identifier (Unique resources; web links)
5	Data are released with the possibility of external interface to Stage 4	LoD, RDF, Schema	LD -- Linked Data (Searchable; conforms to rules for merging information between data sets)

Publicly released Documents for human Comprehension (not editable)

Publicly released documents (editable)

Publicly released data In machine – readable Formats

The 5 Stages of Open Data
Source: Prepared with reference to the Open Data site (http://5stardata.info/) and the website of Tim Berners-Lee regarding linked data (http://www.w3.org/DesignIssues/LinkedData.html).

II. Japan Must Respond to International Developments by Promoting the Paradigm of Open Science

Open science is a concept with the potential to bring about a major transformation in the traditional framework of scientific research activity. Still, this will not be a *replacement* for the research methods used in the past; instead, traditional methods will be complemented by a new set of research techniques that will enable new scientific progress.

By making the results of research widely available in digital formats to *all* users, including the scientific community, the industrial world, and the general population, open science will allow scientific and technological information to be put to use in new ways. Moreover, the ensuing ripple effects will not be limited to the processes by which knowledge is created, but will extend further to revitalize the innovation system throughout society as a whole.

Within the scientific community, we can anticipate an acceleration of data-driven initiatives that transcend the boundaries between both individual researchers and fields of research; this will lead to the diffusion of new collaborations and new research methods. In turn, we can look forward to the birth of new products, new services, and new markets that arise when corporations and individual citizens apply and reuse the results of scientific research.

In particular, for nations such as Japan that lack plentiful natural resources, it is essential to design an environment in which the scientific and technological innovation can lead to a constant production of new value in order to ensure an ongoing continuation of sustainable progress. We must seek a shared recognition among *all* stakeholders that the promotion of open science is a crucial element in the infrastructure underlying such an environment, and we must design a framework for promoting open science on the basis of this recognition.

1. Building a platform for the creation of innovations through application and reuse of the results of scientific research

(1) If changes in the traditional framework of scientific research activity lead to increased access to scientific data, the efficiency and productivity of scientific research will improve. As the sharing (consolidation) of data proceeds, there will be greater opportunity for participation in the research process both within and outside of Japan, enabling more complex and varied research than what would have been possible through traditional initiatives. We must design a framework for ensuring that these effects are effectively realized. In addition, to ensure that future generations of researchers avoid repeating the research of the past, we must build a platform for the application and reuse of the results of scientific research, including articles and research data.

(2) Even without a direct connection to the producers of research data, the application of those data to other areas of research may be stimulated (pioneering new fields of research) by public announcement of the existence of data. We must create a framework in which such announcements lead to the creation of new knowledge and innovations.

(3) We must build platforms that enable all users to apply and reuse data produced as the fruit of research activity, either by making it easy to discern the location of the data or by improving situations in which the data are inaccessible (after the end of a project).

(4) We must design platforms for collecting and storing data that improve on the present situation, in which the departure of an important researcher from a workplace or from a project often leaves behind no successor who can understand and maintain valuable data, whereupon the data are ignored or destroyed.

(5) We must design a framework for ending the serials crisis, that is, for improving the current situation in which access to research results (articles) has become difficult at many universities and similar institutions due to the skyrocketing cost of subscriptions to online journals.

(6) To stimulate innovation, it is essential to train personnel capable of solving problems and to treat the newest knowledge and data in other fields, together with the latest research findings, on a comprehensive, unified footing. To this end, from the perspective of personnel development, the design of foundational platforms for sharing results and data must be considered an essential imperative for Japan's future.

2. Ensuring the quality and transparency of research results

(1) We must acknowledge the simple fact that the increasing complexity and specialization of science and technology has made it difficult to attract understanding and support from society as a whole. We must design systems for making the results of research publicly available as a means of ensuring societal trust.

(2) We must acknowledge the possibility of avoiding problems such as the inability of future generations, working in eras at which science and technology have progressed further, to confirm or falsify past results. For this purpose, it is essential to build platforms capable of providing long-term storage of articles and research data.

(3) The open disclosure of articles and research data is also important from the standpoint of preventing research improprieties. We must take steps to ensure the transparency and fairness of scientific and technological progress, as well as research activities.

3. The increasing role of the humanities and social sciences in promoting open science

Japan's Fourth Science and Technology Basic Plan calls for a "unified rollout of science and technology innovation policies" that would advance scientific and technological policies and policies to promote innovations related to science and technology in a unified manner. Moreover, as the relationship of science and technology to society becomes increasingly intimate, it is essential to view scientific and technological innovation policy as but one piece of *social and public-interest policy* as a whole. These policies must be advanced with the understanding and trust of the citizenry, based on broad participation from the general population. To this end, we must carry out the planning, enactment, and promotion of policies based on objective evidence, such as steps to make the societal effects and influences of scientific and technological innovation more visible, therefore ensuring a more reasonable policy-formation process. Moreover, we must accept a higher level of responsibility for explaining things to the nation's population.

From this perspective, one way to promote open science is to encourage research by scholars in the humanities and social sciences on the problems surrounding the relationship between science and technology and society, including science and technology for the benefit of society and science and

technology as part of society. We can expect such an initiative to lead to active intervention efforts based on the results of this research.

4. The disadvantages to Japan of falling behind global trends

Although Japan has seen some initiatives toward open access to journal articles, to date, there has been inadequate organized discussion surrounding research data; this may lead to some unfortunate consequences for Japan. If Japan is to retain its authority as a communicator on the international stage, it must actively seek collaborations with foreign countries, such as the nations of Europe, North America, and Asia, while retaining its unique strengths. We must be aware of the fact that, if Japan's scientific community falls behind the curve on open science, Japanese researchers may be left behind, leading to a decline in the quality of Japanese science as a whole. If Japan does not demonstrate adequate compliance with the transition to open research data, the sharing of research data which rightly deserve to be shared will be impeded; in this case, Japan will be unable to participate in research pursued on a global scale, resulting in negative consequences such as a decline in Japan's international competitiveness. If this happens, the achievements of Japanese researchers will not be properly reflected on the international stage, and Japan may be left behind by the rest of the world, ensuring a decline in international awareness of Japanese science and technology.

(A) Disadvantages of failing to advance the paradigm of open science

(i) Deleterious impacts on global-scale research

If Japan does not demonstrate adequate compliance with the transition to open research data, the sharing of research data which rightly deserve to be shared will be impeded; in this case, Japan will be unable to participate in research pursued on a global scale, resulting in negative consequences such as a decline in Japan's international competitiveness. If this happens, the achievements of Japanese researchers will not be properly reflected on the international stage, and Japan may be left behind by the rest of the world, ensuring a decline in international awareness of Japanese science and technology.

(ii) Deleterious impacts on the efficiency of research activity in Japan and on Japanese communication with the rest of the world

If Japan is unable to demonstrate clear intentions regarding basic policies and other measures, then the formation of de facto standards for the transition to open science will be driven by foreign countries, which may result in disadvantages for research activities in Japan, as well as for international communication.

(iii) Japan's descent into invisibility on the world's stage

As the transition to open science proceeds worldwide, and the bidirectional exchange of published results and data becomes increasingly active, research that remains closed off within Japan may experience a relative decline in importance.

Consequently, the achievements of Japanese researchers may not be properly appreciated, and Japanese researchers may lose opportunities for overseas research and international research collaborations.

(B) Ramifications for Japan as seen in the key features of the RDA (Research Data Alliance) discussions

The RDA has been a global leader of discussions regarding the openness of research data. Japan must not only familiarize itself with the latest developments in these discussions, but also take steps to clarify the basic Japanese positions on these matters. We must join the circle of discussions and establish our nation as a participant whose footing is equivalent to that of other nations.

(i) Key features of RDA discussions

(a) They proceed rapidly.

Working groups established within the RDA are expected to produce results, such as the preparation of technical papers summarizing their recommendations, at intervals of 12-18 months.

(b) They have significant ripple effects.

The discussions include participation from U.S. and European Commission, Australia, the U.K., Canada, the International Council for Science (ICSU), various government institutions, various international organizations, universities, and other groups.
(This was also reported at a meeting of G8 science ministers)

(c) Disadvantages and risks of non-participation by Japan

Discussions in the direction of forming de facto global standards are proceeding at an accelerated pace. At present, input from Japan is not being adequately incorporated into this process.

(ii) Ramifications for Japan

For areas and technologies for which discussions are not conducted outside of the RDA, the findings of RDA investigations are used as highly influential inputs for the rule-making process, and have a high likelihood of becoming effective rules. If, outside the RDA, there is no forum for investigation, the RDA effectively controls discussions in the relevant areas, and may become the de facto rule-maker.

III. Japan's Response to International Developments in Open Science

1. Clarifying Japan's basic posture and basic policies

The basic posture of open science promotion in Japan is to expand the promotion of the applied use of the results of publicly funded research, including articles and research data. To this end, all stakeholders, including government agencies, funding institutions, universities, and other research institutions, must bear responsibility for both implementing open science initiatives and formulating policies and plans for its implementation. In this process, the common points and issues worthy of note will be clarified as the basic policy regarding open science. Stakeholders such as government agencies must carefully select areas and projects in which open science should be promoted, and then take pains to incorporate the viewpoints of experts, researchers, and engineers in individual fields of research regarding questions such as the benefits and harms of scientific research activities and decisions regarding the handling and fine points of research applications. The objective must be to maximize activity and research results within each area, and for this purpose, open science implementation policies must be established. With regard to the promotion of open science, the Cabinet Office and the Council for Science, Technology, and Innovation, working through the government as a whole, can play a core role as a standard bearer, monitoring the status of each stakeholder's progress.

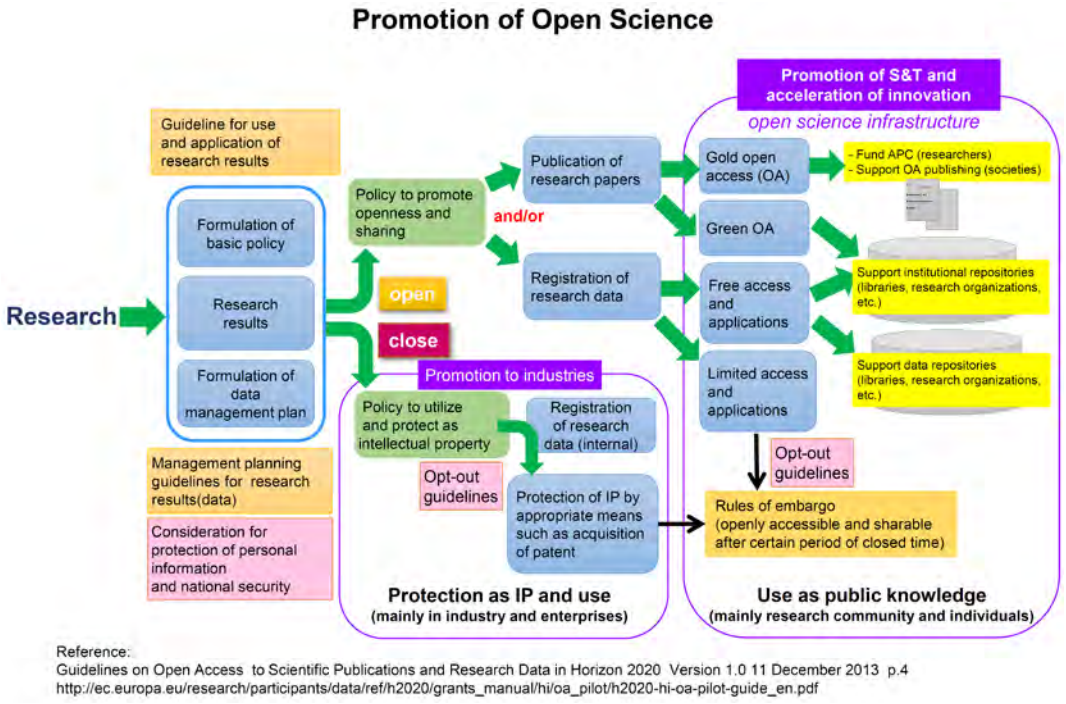


Figure: Schematic diagram depicting the applied use of research results and the promotion of open science

2. Japan's basic philosophy toward the promotion of open science

(A) The significance and objectives of open science promotion

Research supported by public research funds has produced new discoveries and insights that lend strong impetus to progress in many fields, including medicine, energy, the environment, and agriculture. Providing access to the articles and research data that emerge from this publicly funded research can promote greater understanding of those results, inspire new discoveries based on their reuse, and accelerate the pace of innovation and the creation of new research paradigms. This will stimulate the creation of new industries, strengthen competitiveness, and contribute to promoting the causes of research and economic growth around the world.

(B) The range of public disclosure to be promoted by open science

Among the results of publicly funded research, published results and underlying data that serve as evidence for the findings of those published results shall, by default, be publicly disclosed. It is desirable for all other research data obtained as the results of research and development activities to be made public as well, to the extent that this is possible. This will promote data access and data sharing among researchers, universities, and other research institutions both inside and outside Japan, enabling all users to freely apply and reuse the results of research and the creation of new knowledge and value.

Among the results of research considered here, items that are to be considered as *not* subject to the public disclosure imperative include the following: (a) items related to confidentiality, corporate secrecy, national interest or national defense; (b) data collected for the purposes of commercializing or industrializing research results; (c) data possessed by private sector corporations; and (d) the results of research conducted under collaborative research agreements for which disclosure restrictions exist.

In addition, we must design restrictions on the access and use of data that accommodate personal privacy protections and the protection of results for which property rights exist.

(C) The definition of "publicly funded research" and the scope of research data subject to public disclosure

i) The definition of "publicly funded research"
We will define "publicly funded research" to mean research supported by competitive research funds or research funds subject to a public application process. This definition also includes research activities that employ 100% utilization of operational funding grants provided to independent administrative organizations, national universities, or other institutions by the national government.

ii) The scope of research data subject to public disclosure
Research data shall be deemed equivalent to original articles or other results of research and development activity. Research data subject to public disclosure include metadata, numerical data, text records, images, visual data, and various other types of data. By default, the following items are *not* included: research notes, preliminary analyses, drafts of articles, future research plans, private communication with colleagues, physical items (laboratory samples, bacteria strains, experimental animals), and any items for which disclosure is conditional upon agreements with affiliated institutions.