

**Science  
in the Information Society**

***Resource Document***

*Background document prepared for  
the Workshop “Science in the Information Society”*

**UNESCO  
Paris, France  
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## **Introduction**

This document is a compilation of selected background information on some of the major issues of importance to the science community in the context of the information society. Also incorporated in this background information are the initial contributions to the Online Discussion Forum (ODF) being held by International Council of Science (ICSU) from February 8 through March 7, 2003. This information is intended to help the participants of the ICSU/CODATA/UNESCO Workshop on "Science in the Information Society", Paris, March 12, 2003. The aim of this Workshop is to formulate input from the international science community to the UN World Summit on the Information Society (WSIS). This resource document does not attempt to review all the information available but highlights some selected recent material, mainly from the sponsor organizations, in order to provide some context for the Workshop discussions.

### **Importance of the WSIS to Science and vice-versa**

The main building block of the Information Society is the science of Information and Communication Technologies (ICT), which can itself be used should be used as a means to promote a free and open exchange of scientific and technical information (STI). Just as Science is critical to the advancement of the information society, open access to STI is critical for the advancement of science. Recent legal, economic, and technical pressures pose a threat to the Public Domain and principle of universality of science. Hence, it is important that the international science community, participates in the preparations for WSIS, and tries to influence the outcomes such that due account is taken of: i) the importance of science for the future development of the information society, and ii) the needs of the scientific community from that information society as necessary for the advancement of science and for the benefit of society as a whole.

## **Key Principles**

**ICSU**, as a representative body of the world science community adheres to the following key principles, which guide all its deliberations and activities.

### ***1. Universality of science***

ICSU was founded on the principle of the universality of science, which is embedded in its statutes. This principle entails freedom of association and expression, access to data and information, and freedom of communication and movement in connection with international scientific activities, without any discrimination whatsoever.

The principal objectives of ICSU, as defined in its statutes, are:

### ***2. Promoting science for the benefit of humanity***

To encourage and promote international scientific and technological activities for the benefit and well being of all humanity.

### ***3. Promoting scientific resources***

To promote and participate in strengthening of human and scientific resources worldwide with particular emphasis on the developing world.

#### **4. Promoting public understanding of science**

To engage in activities, which promote public understanding of science, so it may play a more meaningful role in society's decision-making and governance.

#### **ICSU/CODATA Principles for Science in the Internet Era**

In response to new proposed legal regimes which would reduce the Public Domain and threaten open access to scientific data, an ICSU/CODATA *ad hoc* Group on Data and Information was established. In June 2000, this Group published a core set of principles to support full and open access to data needed for scientific research and education. (See Appendix 1 for full text). These principles can be summarized as follows:

##### **1. Science is an investment in the public interest**

##### **2. Scientific advances rely on full and open access to data.**

The tradition of full and open access to data has led to breakthroughs in scientific understanding, as well as to later economic and public policy benefits. The idea that an individual or organization can control access to or claim ownership of the facts of nature is foreign to science.

##### **3. A market model for access to data is unsuitable for research and education.**

Practices that encourage data sharing are necessary to advance science and to achieve the resulting social benefits. Data sharing is possible only when data is affordable. If data are formally made available for scientific access, but the prices charged for such access are prohibitively high, the negative impact on science is the same as if access had been legally denied. This is especially the case for scientists in developing countries.

##### **4. Publication of data is essential to scientific research and the dissemination of knowledge.**

A restriction on data publication or a requirement that colleagues recompile a database from original sources compromises the ability of scientists to advance knowledge.

##### **5. The interests of database owners must be balanced with society's need for open exchange of ideas.**

Legal foundations and societal attitudes should foster a balance between individual rights to data and the public good of shared data.

##### **6. Legislators should take into account the impact intellectual property laws may have on research and education.**

#### **Organization of the scientific in-pur for WSIS under four themes**

In application of the above guiding principles to the context of growth of the information society through the scientific means of Information and Communication Technologies (ICT), four overarching themes have been proposed for consideration at the Workshop on 12<sup>th</sup> March. These

four themes have also been adopted for an Online Discussion Forum (ODF) which is currently being conducted by ICSU. The themes are:

1. **Scientific information for decision-making and better governance.**
2. **Ensuring universal access to scientific knowledge internationally, including overcoming the “digital divide”.**
3. **Scientific data and information as a global public good.**
4. **Using scientific data and information in improving all levels of education and training.**

In preparation for the ODF, selected experts were invited to contribute their own personal reflections on these themes. Full texts of these contributions can be found on ICSU Online Discussion Forum website ([www.icsu.org](http://www.icsu.org)).

### **Theme 1. Scientific information for decision-making and better governance**

Science plays an increasingly significant role in identifying and analyzing the challenges faced by society and in generating the knowledge to respond to these challenges. Without scientific input, there would not be any objective criteria to investigate the problems, and means to find rational solutions to those problems.

#### **Contributions to the ICSU Online Discussion Forum**

Mr. John Rumble, Jr., member, CODATA, in his introduction of the theme, provocatively suggested that, whilst science invented the information society with its ICT, the science community is not sufficiently interested in how the public finds and uses scientific information and how the decision makers understand and use science in their policy and decision making processes. He suggested that in addition to furthering science, the science community must participate actively in the following activities:

- 1) Explaining science to the citizenry and decision makers.
- 2) Reporting honestly and to the broadest spectrum of the society.
- 3) Explaining effectively the value of certainty/uncertainty in decision-making.

Ms. Vanessa Thomas, Knowledge Management Division, South Africa Medical Research Council (MRC), stated that MRC is developing a Research Translation Unit to guide the transfer of scientific knowledge to the general public, and to evaluate the impact of health research. Such programs if successfully implemented could serve as models of best practices and could be duplicated in other fields of science.

#### **Other recent reports/activities**

##### ***Scientific data for decision making for sustainable development – Senegal River Basin Study***

The U.S. National Committee for CODATA, Senegalese National CODATA Committee, and the National research council of the U.S. National Academies, published this study in 2002, after a workshop of experts held in Dakar, Senegal, on March 11-15, 2002. ( report published by National Academies Press, Washington D.C., [www.nap.edu](http://www.nap.edu)). The Study identified a number of important policy issues affecting use of data for decision-making. Although some of the issues are particular to the subject of the case study, many are generic to the conditions in least

developed countries (LDCs), and give an insight into the dynamics of decision-making processes and role of science in these processes.

Some of the important policy issues identified by the study are as follows:

1. Scientific data in particular need to be used and integrated from research into policy and decision making whenever appropriate. The process for this may be simply described as follows: data → information → knowledge → understanding → decision making at different levels
2. There is a role for the scientific community in the policy process. Scientists can act as “policy entrepreneurs” to help bring issues to the attention of decision makers and the public.
3. For data collection and analysis, as well as for the use of the data in decision-making, there are political and ideological biases and barriers. An important issue is the requirement for clear credibility on the part of the data holders and decision makers.
4. Related to the immediately preceding issue is the need to involve all stakeholders, including the people from the communities directly affected, in the problem management and policy formation.
5. Who the messenger is can be as important as what the message is. There is a need to use trusted people who speak the local language in converting and diffusing the knowledge derived from the original data into relevant public action.
6. For poor countries, the requirements for collection of comprehensive and reliable data are nonetheless seen by many as a luxury that benefits an army of consultants but not the poor people. It is therefore important to prioritize and adequately justify the data collection activities.

## **Theme 2. Ensuring universal access to scientific knowledge internationally, including overcoming the “digital divide”**

The ICT revolution of the past decade has had a tremendous positive impact in many countries. The least developed countries (LDCs), however, have generally not been able to fully realize the benefits of ICT. This can be at least partially ascribed to the lack of resources to establish adequate networks of hardware and software, required to access STI. In addition to the financial resources, many of these countries also lack adequate regional and country organizations to take leadership roles, and sometimes there is lack of political will and vision to reform the existing technological, economic, and legal regimes. Due to all these barriers, the so called ‘digital divide’ between the developed countries and the LDCs has been widening. There is, therefore, an urgent need for a concerted effort to assist the LDCs with ICT in order to bridge this divide.

### **Contributions to the ICSU Online Discussion Forum**

Dr. Carol Priestley, Director, International Network for the Availability of Scientific Publications (INASP), in her introduction to this theme has pointed out some of the issues, which need to be addressed:

1. Low level of connectivity in developing countries is preventing access to or utilization of resources, that are now available.

2. The trend towards commercial access of digital STI has serious implications for researchers and publishers everywhere.
3. There is a need for promoting intra-regional information and enabling research results from developing regions to be accessed and promoted worldwide.

Dr. Priestley cited two examples of programs “designed to enable scientists, public health workers, researchers and policy makers in developing countries to access high quality relevant and timely information in affordable and sustainable ways”. They are a) Programme for the Enhancement of Research Information (PERI) of the INASP; and b) the Health Inter Network Access to Research Initiative (HINARI) of WHO. More information about PERI may be accessed from the INASP website ( [www.inasp.info/peri/](http://www.inasp.info/peri/)).

Professor Eric Odada, University of Nairobi, Kenya, in his introduction to this theme has stressed the need to develop strategies to utilize the ICT that are appropriate to fulfill the particular needs of each developing country.

In addition to the issue of lack of adequate connectivity, Prof Odada also raises the issue of need to organize education and training programs on how to use ICT, for example, how to look for good information, and how to connect to virtual libraries and online journals.

Mr. Sadanand Balaram, Simon Fraser University, Canada, suggested that the UN Sustainable Development Network Program (SDNP) of UNDP would be a good organization to implement the development and maintenance of the required network infrastructure for LDCs.

### **Theme 3. Scientific information as a global public good**

During the last decade, there have been significant developments in ICT, in legal regimes of intellectual property rights and licensing, and in methods of commercialization of STI. These changes in technology, law, and economics of data access and dissemination have created a tension between the natural and traditional public interest in a thriving Public Domain and open universal access, and the market economy commercial interest of acquisition, ownership, licensing, and sale of the STI, especially of the scientific data. The science community in collaboration with other institutions and national governments needs to come up with some new creative ways to balance these two competing interests, protect the Public Domain and ensure open universal access.

#### **Contributions to the ICSU Online Discussion Forum**

In his introduction to the theme in the ODF, Mr. Barry Mahon of International Council for Scientific and Technical Information (ICSTI) has identified three major issues:

1. How to preserve and promote access to and sharing of public scientific resources without unduly restricting new opportunities for commerce;
2. In what location, and in what form to archive data and information so that it is universally accessible at reasonable cost.
3. How to overcome the inability of researchers and other users in developing countries, especially the LDCs, to access scientific information since they cannot afford the capital and operating costs associated with data networks, thus leading to a digital divide.

Mr. Kurt N. Molholm, President of ICSTI, has suggested the use of technology-based networks, to network the content and distribute it:

“A network is an array of resources—both people and digital—a whole, a complex configuration that offers possibilities with far greater potential than the sum of its parts. The need for the free-flow of public domain information and data as a foundation for research and knowledge expansion offers an opportunity to change the current environment and relationships by networking content and making it available to many communities. Using capabilities such as XML, the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH), the Handle System®, and the Dublin Core metadata standard, a technology-based environment of distributed but interlinked information sources can advance the information society by providing content through technology”.

### **Other recent reports/activities**

#### ***OECD Report: “Promoting Access to Public Research Data for Scientific Economic and Social Development”***

*In February 2003, Organisation for Economic Co-operation and Development (OECD) issued its Final Report on “Promoting Access to Public Research Data for Scientific, Economic, and Social Development” (see appendix 2 for the Executive Summary) in which it identified five broad areas or groups of issues that need to be addressed.*

1. Technological issues: broad access to research data, and their optimum exploitation, requires appropriately designed technological infrastructure, broad international agreement on interoperability, and effective data quality controls;
2. Institutional and managerial issues: the diversity of the scientific enterprise suggests that a variety of institutional models and tailored data management approaches are most effective in meeting the needs of researchers;
3. Financial and budgetary issues: The use of research data cannot be maximized if access, management and preservation costs are an add-on or after-thought in research projects;
4. Legal and policy issues: national laws and international agreements are often adopted without due consideration of the impact on the sharing of publicly funded research data; and
5. Cultural and behavioral issues: appropriate reward structures are a necessary component for promoting data access and sharing practices.

#### **National Academies USA Symposium: “The Role of Scientific and Technical Data and Information in the Public Domain”, September 2002**

At this recent international symposium, Dr. Jerome Reichman, Professor, Duke University Law School, and Dr. Paul Uhlir, Director of International STI Programs, National Academies, identified some of the pressures on the Public domain as follows:

“In addition, recent changes to copyright law and the widespread use of licensing contracts of adhesion in commerce—as well as exclusive licensing agreements on onerous terms for research tools and technologies in academia—are further diminishing the availability of public-domain data in science. These highly protectionistic legal mechanisms are increasingly enforced by more effective digital rights management technologies. Such developments are intensifying the tensions that already exist between the traditional sharing norms of science and the growing need to restrict access to and uses of data in pursuit of increased commercial

opportunities. New restrictions on access to and dissemination of potential sensitive research data and information are further constraining the availability of substantial amounts of material in the public domain. Finally, the recent enactment of a powerful new database protection statute in Europe and proposals for equivalent legislation in the United States might be expected to push these tensions into other areas of public research, heretofore less affected by the commercialization and privatization trend.”

The speakers at the symposium identified some of the negative effects of these pressures:

- Less effective domestic and international scientific cooperation, with serious impediments to the use, reuse, and transformation of factual data;
- Increased transaction costs.
- Higher pricing of data and anti-competitive practices by entities that acquire monopoly market power, or by first entrants into niche markets;
- Less data-intensive research and pervasive lost opportunity costs.
- Disruption of long-established scientific research practices and to the loss of new opportunities that digital networks and related technologies make possible

#### **Theme 4. Using scientific data and information in improving all levels of education and training**

ICT has made a tremendous impact on education and training in many developed countries, which in turn has led to the growth of the information society. This same success can be repeated elsewhere by using appropriate ICT to create infrastructure tailored to the need of particular countries and regions. Without education and training to access and utilize STI efficiently and effectively, there will not be any significant and sustainable development even if STI is freely available.

##### **Contributions to the ICSU Online Discussion Forum**

In his theme introduction for the ODF, Professor Burt Richter, Stanford Linear Accelerator, points out the need to create necessary infrastructure to support the education and training programs by using appropriate ICT. He points out that it is not realistic to think of programs that require high-speed, two-way communication for use at all levels of education and training. He differentiates between education and training and recommends use of low-level technologies for training purposes.

At the university and other higher education level, it would be appropriate to use internet where both teachers and students have free access to STI and to curricular materials and teaching methods developed elsewhere. This would limit the infrastructure costs and make the education more cost effective. This would require the national governments to make available appropriate bandwidth at reasonable cost. At the secondary education level, he recommends physical distribution of educational materials to teachers as well as students because it would cost much less and reach a larger number of sites. At the level of training which would include training of primary education teachers, craftsmen and farmers it might be more efficient to use training videos. They are mobile materials, and can be reused effectively.

Professor Richter proposes that the governments in the developed world could assist with major facilities such as fiber optic links and satellites to distribute the material and the developing countries could participate by making investment in affordable interior infrastructure.

Mr. W. J. Rourke, Special Advisor to President, World Federation of Engineering Organizations (WFEO), pointed out that since the term Science is interpreted by some as being a research activity it on the frontiers of knowledge, it would be better to use a broader term Science, Engineering and Technology (SET) to describe comprehensive scientific and technological activities at all levels. He emphasized the need to transfer SET information at appropriate levels depending on the particular needs of the developing countries. He also supported the idea of virtual global libraries with free access and stated that WFEO is now working with UNESCO to establish Virtual Environment and Sustainable Systems Engineering Library (VESSEL) Network to provide STI to developing countries at the high school, technical college and university levels. For more details please see [www.unesco.org/wfeo/](http://www.unesco.org/wfeo/).

Mr. Shivanand Balram, Simon Fraser University, Canada pointed out that in some developing countries a change of attitude is needed to modify or dismantle their existing traditional infrastructure in order to accommodate the newer ICT based learning.

Ms. Lorna Malicsi, Department of Science and Technology, Philippines, noted two problems facing the Philippines. Firstly, a lack of political will among the decision makers to invest in ICT based education. Secondly, and lack of a dialogue between the researchers and the potential end users such as farmers, with the result that the researchers keep producing the scientific information without regard to its dissemination and benefit to the end users, and the end users are distrustful and sceptical that any benefit can be derived from the scientific information.

### **Other recent reports/activities**

#### ***UNESCO Forum on the Impact of Open Courseware for Higher Education in Developing Countries, July 2002***

A UNESCO Forum on the Impact of Open Courseware for Higher Education in Developing Countries was held in Paris on 1-3 July 2002 (full report available on [www.unesco.org](http://www.unesco.org)). The Forum was convened specifically to discuss development and use of Open Educational Resources (OER), as a tool to further the educational needs of the developing world. It examined MIT's Open Course Ware (OCW) Initiative, which plans to make materials from approximately two thousand courses freely available for use by faculties and students everywhere. It is not a long distance learning programme but a plan to provide free universal access to the course content and other teaching material, and to create an efficient standards-based model that can be used by other universities.

The UNESCO Forum focused on Higher Education *per se*, and not science education in particular. However, the idea of open courseware can be readily adopted for science and technology education and training. This could be implemented, for example, by forming a consortium of universities and technical institutes to make available online, scientific and

technical course materials to researchers, teachers and students. In this context, MIT's OCW Initiative can serve as a model for in using ICT for science education and training.

Global virtual laboratories and libraries can also be used to support scientific research and education worldwide. The National Science Digital Library ([www.nsdlib.org](http://www.nsdlib.org)), the VESSEL network of UNESCO/WFEO, and Global Library Initiative ([globallibrary.org](http://globallibrary.org)) are examples of such global virtual libraries.

## APPENDIX 1

### ACCESS TO DATABASES

#### A Set of Principles for Science in the Internet Era

Prepared by the ICSU/CODATA Ad Hoc Group on Data and Information

ICSU, CODATA and their member organizations have become increasingly concerned about proposals to the World Intellectual Property Organization and various national legislatures to introduce a new form of intellectual property protection for the contents of databases. This protection would fall outside traditional patent and copyright regimes. To address these issues from the perspective of working scientists, ICSU and CODATA have established a joint ad hoc Group on Data and Information. The Group believes that the database proposals will have a deleterious effect over time on the progress of science and on the translation of scientific advances into new technology and enhanced economic development. The Group does recognize that the threat of piracy could become a potential disincentive to the creation of new value-added scientific databases. However, the proposed solutions to a problem that has not been clearly identified would have a serious negative impact on science and on society at large.

This document proposes a core set of principles to support full and open access to data needed for scientific research and education. The needs of science must harmoniously co-exist with the burgeoning information industry. A balance between the two is needed. A healthy research community is critical for society to prosper, for research generates the information commodities of the future. At the same time, information as an economic activity has spawned countless new companies and businesses worldwide. ICSU and CODATA believe that full awareness of these principles by scientists, businessmen, legislators, and regulators can foster a working partnership in which everyone gains. Comments on the document are welcome.

ICSU, now called the International Council for Science, was created in 1931 to promote international scientific activities in all areas of natural science and their applications for the benefit of humanity. More than 135 nations adhere to ICSU or its scientific unions. Since its creation, a major objective of ICSU has been to assure that scientists in all nations can obtain access to data and other types of technical information that are essential to their work. CODATA, the Committee on Data for Science and Technology, is an interdisciplinary scientific committee of ICSU, which works to improve the quality, reliability, management, and accessibility of data of importance to all fields of science and technology.

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## Principles for dissemination of scientific data

Prepared by the ICSU/CODATA Ad Hoc Group on Data and Information

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Scientists are both users and producers of databases. However, scientific databases are seldom static; in the course of their research, scientists frequently draw on several existing databases to create a new database tailored to specific research objectives. The synthesis of data from different sources to provide new insights and advance our understanding of nature is an essential part of the scientific process. The history of science is rich with examples of data collections that played a crucial part in a scientific revolution, which in turn had a major impact on society. It may truly be said that data are the lifeblood of science.

The Group proposes the following set of principles for organizations and individuals to evaluate legislative proposals that affect the use of scientific databases.

1. **Science is an investment in the public interest.** Through research and education, scientists foster the creation and dissemination of knowledge. This can have profound effects on the well being of people and the economies of the world. Science is a critical public investment in our future, a resource with extraordinary dividends.
2. **Scientific advances rely on full and open access to data.** Both science and the public are well served by a system of scholarly research and communication with minimal constraints on the availability of data for further analysis. The tradition of full and open access to data has led to breakthroughs in scientific understanding, as well as to later economic and public policy benefits. The idea that an individual or organization can control access to or claim ownership of the facts of nature is foreign to science.
3. **A market model for access to data is unsuitable for research and education.** Science is a cooperative, rather than a competitive, enterprise. No individual, institution, or country can collect all the data it needs to address important scientific issues. Thus, practices that encourage data sharing are necessary to advance science and to achieve the resulting social benefits. Such data sharing is possible within tight research budgets only when data are affordable. If data are formally made available for scientific access, but the prices charged for such access are prohibitively high, the negative impact on science is the same as if access had been legally denied. This is especially the case for scientists in developing countries.
4. **Publication of data is essential to scientific research and the dissemination of knowledge.** The credibility of research results depends on the publication of data that back them up and permit reproduction of the results by colleagues. A restriction on data publication or a requirement that colleagues recompile a

database from original sources compromises the ability of scientists to advance knowledge.

5. ***The interests of database owners must be balanced with society's need for open exchange of ideas.*** Given the substantial investment in data collection and its importance to society, it is equally important that data are used to the maximum extent possible. Data that were collected for a variety of purposes may be useful to science. Legal foundations and societal attitudes should foster a balance between individual rights to data and the public good of shared data.
6. ***Legislators should take into account the impact intellectual property laws may have on research and education.*** The balance achieved in the current copyright laws, while imperfect, has allowed science to flourish. It has also supported a successful publishing industry. Any new legislation should strike a balance while continuing to ensure full and open access to data needed for scientific research and education.

Paris, June 2000

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## **APPENDIX 2**

### Promoting Access to Public Research Data for Scientific, Economic, and Social Development

OECD Follow Up Group on Issues of Access to  
Publicly Funded Research Data

**March 2003**

**Participants from the United States are being funded through NSF Grant ACI-9619020 to help coordinate this group's activities and develop a series of case studies to explore data access issues. Additional support for the group's activities comes from the Netherlands' Ministry of Education, Culture and Science, CODATA, and governments and agencies of the group's members. The European Science Foundation is a partner in this activity. Finally, the Netherland's Ministry for Education, Culture and Science funded the publication of two studies conducted by this group**

## **Executive Summary**

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It is now commonplace to say that information and communications technologies are rapidly transforming the world of research. We are only beginning to recognize, however, that management of the scientific enterprise must adapt if we are, as a society, to take full advantage of the knowledge and understanding generated by researchers. One of the most important areas of ICT-driven change is the emergence of e-science, briefly described as universal desktop access, via the Internet, to the intellectual, analytical, and investigative output of the world's scientific community.

The vision of e-science is being realized in relation to the outputs of science, particularly journal articles and other forms of scholarly publication. This is much less so with research data, the raw material at the heart of the scientific process and the object of significant annual public investments.

Ensuring research data are easily accessible, so that they can be used as often and as widely as possible, is a matter of sound stewardship of public resources. Moreover, as research becomes increasingly global, there is a growing need to systematically address data access and sharing issues beyond national jurisdictions. To ensure that both researchers and the public receive optimum returns on the public investments in research, and to build on the value chain of investments in research and research data, are the goals of this report and its recommendations.

To some extent, research data are shared today, often quite extensively within established networks, using both the latest technology and innovative management techniques. The Follow Up Group drew on the experiences of several of these networks to examine the roles and responsibilities of governments as they relate to data produced from publicly funded research. The objective was to seek good practices that can be used by national governments, international bodies, and scientists in other areas of research. In doing so, the Group developed an analytical framework for determining where further improvements in the national and international organization, management, and regulation of research data can be made.

The findings and recommendation presented here are based on the central principle that ***publicly funded research data should be openly available to the maximum extent possible.*** Availability should be subject only to national security restrictions; protection of confidentiality and privacy; intellectual property rights; and time-limited exclusive use by principal investigators. Publicly funded research data are a public good, produced in the public interest. As such they should remain in the public realm. This does not preclude the subsequent commercialization of research results in patents and copyrights, or of the data themselves in databases, but it does mean that a copy of the data must be maintained and made openly accessible. Implicitly or explicitly, this principle is recognized by many of the world's leading scientific institutions, organizations, and agencies. Expanding the adoption of this principle to national and international stages will enable researchers, empower citizens and convey tremendous scientific, economic, and social benefits.

Evidence from the case studies and from other investigation undertaken for this report suggest that successful research data access and sharing arrangements, or regimes, share a number of key attributes and operating principles. These bring effective organization and management to the distribution and exchange of data. The key attributes include: openness; transparency of access and active dissemination; the assignment and assumption of formal responsibilities; interoperability; quality control; operational efficiency and flexibility; respect for intellectual property and other ethical and legal matters; accountability; and professionalism. Whether they are discipline-specific or issue oriented, national or international, the regimes that adhere to these operating principles reap the greatest returns from the use of research data.

There are five broad areas or groups of issues that stand out in any examination of research data access and sharing regimes. The Follow Up Group used these as an analytical framework for examining the case studies that informed this report, and in doing so, came to several broad conclusions:

- Technological issues: broad access to research data, and their optimum exploitation, requires appropriately designed technological infrastructure, broad international agreement on interoperability, and effective data quality controls;
- Institutional and managerial issues: while the core open access principle applies to all science communities, the diversity of the scientific enterprise suggests that a variety of institutional models and tailored data management approaches are most effective in meeting the needs of researchers;
- Financial and budgetary issues: scientific data infrastructure requires continued, and dedicated, budgetary planning and appropriate financial support. The use of research data cannot be maximized if access, management, and preservation costs are an add-on or after-thought in research projects;
- Legal and policy issues: national laws and international agreements directly affect data access and sharing practices, despite the fact that they are often adopted without due consideration of the impact on the sharing of publicly funded research data;
- Cultural and behavioural issues: appropriate reward structures are a necessary component for promoting data access and sharing practices. These apply to both those who produce and those who manage research data.

The case studies and other research conducted for this report suggest that concrete, beneficial actions can be taken by the different actors involved in making possible access to, and sharing of, publicly funded research data. This includes the OECD as an international organization with credibility and stature in the science policy area. The Follow Up Group recommends that the OECD consider the following:

- Put the issues of data access and sharing on the agenda of the next Ministerial meeting;
- In conjunction with relevant member country research organizations,
  - Conducting or coordinating a study to survey national laws and policies that affect data access and sharing practices;
  - Conducting or coordinating a study to compile model licensing agreements and templates for access to and sharing of publicly funded data;
- With the rapid advances in scientific communications made possible by recent developments in ICTs, there are many aspects of research data access and sharing that

have not been addressed sufficiently by this report, would benefit from further study, and will need further clarification. Accordingly, further possible actions areas include: Governments from OECD expand their policy frameworks of research data access and sharing to include data produced from a mixture of public and private funds; OECD consider examinations of research data access and sharing to include issues of interacting with developing countries; and OECD promote further research, including a comprehensive economic analysis of existing data access regimes, at both the national and research project or program levels.

National governments have a crucial role to play in promoting and supporting data accessibility since they provide the necessary resources, establish overall policies for data management, regulate matters such as the protection of confidentiality and privacy, and determine restrictions based on national security. Most importantly, national governments are responsible for major research support and funding organizations, and it is here that many of the managerial aspects of data sharing need to be addressed. Drawing on good practices worldwide, the Follow Up Group suggests that national governments should consider the following:

- Adopt the principle that data produced from publicly funded research should be openly available to the maximum extent possible;
- Encourage their research funding agencies and major data producing departments to work together to find ways to enhance access to statistical data, such as census materials and surveys;
- Adopt free access or marginal cost pricing policies for the dissemination of research-useful data produced by government departments and agencies;
- Analyze, assess, and monitor policies, programs, and management practices related to data access and sharing policies within their national research and research support organizations.

The widespread national, international and cross-disciplinary sharing of research data is no longer a technological impossibility. Technology itself, however, will not fulfill the promise of e-science. Information and communication technologies provide the physical infrastructure. It is up to national governments, international agencies, research institutions, and scientists themselves to ensure that the institutional, legal, economic, and cultural and behavioural aspects of data sharing are taken into account.