Science in the Information Society

UNESCO Publications for the World Summit on the Information Society

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Preface

UNESCO has fully supported the World Summit on the Information Society (WSIS) preparatory process from its beginning and has made a significant contribution to the work on the Declaration of Principles and the Plan of Action that the Summit is expected to adopt. UNESCO's proposals for the Declaration of Principles and the Plan of Action are based on its mandate. This leads it to promote the concept of knowledge societies rather than that of the global information society, since enhancing information flows alone is insufficient to grasp the opportunities for development that are offered by knowledge. Therefore, a more holistic and comprehensive vision, and a clearly developmental perspective, are needed.

The proposals respond to the main challenges posed by the building of knowledge societies: first, to narrow the digital divide that accentuates disparities in development, excluding entire groups and countries from the benefits of information and knowledge; second, to guarantee the free flow of, and equitable access to, data, information, best practices and knowledge in the information society; and third, to build international consensus on newly required norms and principles.

Knowledge societies should be firmly based on a commitment to human rights and fundamental freedoms, including freedom of expression. They should also ensure the full realization of the right to education and of all cultural rights. In knowledge societies, access to the public domain of information and knowledge for educational and cultural purposes should be as broad as possible providing high quality, diversified and reliable information. Particular consideration should be given to the importance of diversity of culture and language.

In knowledge societies, the production and dissemination of educational, scientific and cultural materials, the preservation of digital heritage and enhancing the quality of teaching and learning, should be regarded as crucial elements. Networks of specialists and of virtual interest groups should be developed, as they are the key to efficient and effective interaction and cooperation in knowledge societies. Information and communications technology (ICT) should be seen both as a pedagogical tool and as a discipline in its own right for the development of effective educational services.

These technologies are not merely tools; they inform and shape our modes of communication and our thinking and creativity processes. How should we act so that the benefit of this ICT revolution accrues to all mankind and does not become just the privilege of a small number of economically highly developed countries? How can we ensure access for all to these information and intellectual resources, and overcome the social, cultural and linguistic barriers to participation in knowledge societies? How should we promote the online publication of content that is increasingly more diversified and potentially a source of enrichment for the whole of humanity? What teaching and learning opportunities are offered by these new means of communication?

These are crucial questions to which answers must be found if knowledge societies are to become a reality and offer the opportunity for interaction and enrichment on a global scale. They are also questions which the stakeholders in the development of knowledge societies – States, private enterprise and civil society – must answer together.

On the occasion of the World Summit on the Information Society, UNESCO intends to make available to all participants a series of documents that will discuss the above issues of concern. They will also refer to the development potential of ICT, problems and solutions, and various projects implemented by UNESCO and its many partners. It is hoped that this information will encourage ongoing debate and assist participants to evaluate the significant impact, and the potential, of the emergence of the new ICTs.

Abdul Waheed KHAN
UNESCO’s Assistant Director-General
for Communication and Information

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Overview

From the printing press to the World Wide Web

The emergence of the information society is a revolution comparable to the deep transformation of the world engendered by the dual inventions of the alphabet and the printing press

Walter Erdelen
Assistant Director-General for Natural Sciences, UNESCO

In 1572, it took three days for the news of the bloody slaughter of protestants during the night of the Saint Bartholemy to travel from Paris to Madrid. In 2003, it would take only a few seconds. E-mail enables people on opposite sides of the world to obtain information in the twinkling of an eye. They need only settle down comfortably in front of a computer and navigate over the Internet to learn the latest news from around the world or find the answer to a question. Similarly, scientists may participate in virtual research via the Internet with fellow scientists who may be in the next room or on the next continent.

Just as Johannes Gutenberg revolutionized the world by inventing the modern[1] printing press in the mid-fifteenth century, so Tim Berners-Lee has revolutionized the way information is produced and exchanged by creating the World Wide Web.

Neither is simply a technological revolution. Both have influenced – and continue to influence – the economic, social, cultural and political fabric of most of the world's societies. An Italian writer complained in 1550 that

1. Movable type was used in China as early as the XIth century. However, the Chinese type were made of clay, unlike Gutenberg's which were cast in metal. Gutenberg's method was still in use in the 20th century.

there were so many books in circulation because of the invention of the printing press that he did not even have the time to read all the titles[2]. What would we say today when the world is inundated with a myriad of different yet complementary media transmitting massive volumes of information around the world every second?

The printing press served to expand knowledge and ideas. At the close of the 19th century, the historian Lord Acton described the invention of the printing press as having generated two effects: a horizontal effect, meaning that knowledge would be more accessible to a wider population; and a vertical effect, offering future generations the opportunity to build on the intellectual work of their ancestors[3].

In much the same way that the printing press has expanded human outreach, so the Internet is spreading its net ever wider to envelop an ever-greater number of human beings; it is changing existing rules of how we acquire information, modifying the way people access new knowledge, accelerating procedures and, at the same time, triggering novel values, trends and challenges. The term 'information society' was coined at the turn of the century to describe a society in which information and communication technologies (ICTs) have become an integral part of daily life. It has become second nature to millions of people around the world to use ATM banking machines, listen to a radio, carry a mobile phone, surf the Internet or consult their e-mail inbox, to cite but a few examples.

The role of S&T in the information society

Without science, there would be no information society
Roger Cashmore
CERN

The open exchange of information made possible by the World Wide Web and other information technologies has revolutionized everything from global

2. Briggs, A.; Burke, P. (2002) *A Social History of the Media. From Gutenberg to Internet.*
3. *Ibid.*

commerce to how we communicate with friends and family[4]. Scientific research leads to the development of new technologies and to the production of data and information that, when combined with these technologies, can be of huge benefit to society as a whole.

Sir Roger Elliot, Chair of the Executive Board of the International Council for Science (ICSU) stresses the role scientists play in the development of ICTs, the foundation of the information society. ‘Scientific research, full and open access to scientific information for scientists and improved science education and training’, Elliot says, ‘are all important for raising public understanding of science, in order to enable society to make more informed decisions’[5].

‘The application of scientific knowledge continues to furnish powerful means for solving many of the challenges facing humanity, from food security to diseases such as AIDS, from pollution to the proliferation of weapons’, says United Nations Secretary-General Kofi Annan[6]. “Recent advances in information technology, genetics and biotechnology hold extraordinary prospects for individual well-being and humankind as a whole. At the same time, the way in which scientific endeavours are pursued around the world is marked by clear inequalities. Developing countries, for example, generally spend much less than 1% of their gross domestic product on scientific research, compared to between 1.5% and 3% in wealthy countries. The number of scientists in proportion to population in the developing countries is 10–30 times smaller than in developed countries’. The great majority of new science is created in the North ‘and much of this – in the realm of health, for example – neglects those problems that afflict most of the world’s people’.[7]

4. This and other ideas in this document have been taken from different background documents and papers submitted to the WSIS, Geneva 2003, Tunis 2005.
5. Opening remarks of Sir Roger Elliot from ICSU, at the UNESCO/ICSU/CODATA Workshop on Science and the Information Society, 12 March 2003, UNESCO Headquarters, Paris.
6. A Challenge to the World’s Scientists. (Lead Article) *Science*, 7 March 2003.
7. www.pugwash.org/reports/ees/KofiAnnaninScience299.pdf

The 'digital divide', symptom of a 'scientific divide'

One-fifth of the world's population produces four-fifths of world science
UNESCO Institute for Statistics

According to the Organisation for Economic Co-operation and Development (OECD), 45% of Internet users were based in the USA and Canada in 2000, 27% in Europe, 23% in Asia-Pacific, 3.5% in Latin America and 1.5% in African and Middle Eastern countries. That translates into 2 billion people who have never used the telephone and only 400 million with regular access to Internet, by the estimates of the Latin American Association for Integration (ALADI) in *The digital gap and its effects in the ALADI country members*[8].

Internet users per 100 population in 2001

In countries of 30 million or more inhabitants

Republic of Korea	52.11	Indonesia	1.91
USA	50.15	Kenya	1.60
Canada	46.66	Iran	1.56
Japan	38.42	Morocco	1.37
Germany	37.36	Viet Nam	1.24
United Kingdom	32.96	Ukraine	1.19
Italy	26.89	Bangladesh	0.14
France	26.38	Egypt	0.93
Spain	18.27	India	0.68
Argentina	10.08	Algeria	0.65
Poland	9.84	Pakistan	0.34
South Africa (Rep. of)	6.49	United Republic of Tanzania	0.30
Turkey	6.04	Sudan	0.18
Thailand	5.77	Nigeria	0.10
Brazil	4.66	Ethiopia	0.04
Mexico	3.62	Democratic Republic	
Russian Federation	2.93	of the Congo	0.01
Colombia	2.70	Myanmar	0.01
China*	2.57		
Philippines	2.56	*Hong Kong = 38.68	

Source: http://unstats.un.org/unsd/mi/mi_goals.asp

8. www.aladi.org/NSFALADI/SITIO.NSF/INICIO

The main causes of the digital gap are the wide disparities in: gross national product and the distribution of this among the different social and economic groups; the development of communications infrastructure and; the level of education of citizens. Furthermore, as the ALADI study points out, the cost of individual access to ICTs may limit people's participation in the Web economy.

Mike Jensen[9] stresses that 'models of infrastructure provision are likely to be quite different [in the developing countries] to those in the developed countries because of the generally low income levels, limited formal business activity and the much greater importance of the rural population, where up to 80% of people may live outside urban areas'. He goes on to say that, 'in addressing the low income factor, innovative models may be necessary which focus on shared infrastructure, public access facilities and the use of intermediaries to interact with the public who many not have functional literacy, let alone computer literacy'.

Jensen states that 'Sub-Saharan Africa contains about 10% of the world's population (626 billion) but only 0.2% of the world's 1 billion telephone lines… The penetration of phone lines on the sub-continent is about five times worse than the 'average' low income country'. Although the number of fixed lines increased from 12.5 million to 21 million across Africa between 1995 and 2001, 11.4 million of the new lines went to North Africa and 5 million to South Africa, according to Jensen. On the more positive side, he notes that 'Five years ago, only a handful of countries had local Internet access, now it is available in every city on the continent'. He also states that the situation is not as bad as it might appear because of the penetration of mobile networks, even if 'the high cost of mobile usage makes it too expensive for regular local calls or Internet access'.

While industrial countries can be up to date in the scientific and technological revolution, and run at the same pace as technical change, developing countries have to make huge efforts to gain access to the necessary infrastructure and to acquire the knowledge required to take full advantage of ICTs. It is imperative that a deep change take place in society: a restructuring of marketing and innovation systems, changes in the educational and capacity-building models,

9. Jensen, M. (2003) Network connectivity in Africa – the current status. Proceedings of the Open Roundtable on Developing Countries Access to Scientific Knowledge: Quantifying the Digital Divide, ICTP, 23-24 October 2003.

We need digital solidarity, perhaps founded on a digital charter by which economies higher up on the ICT development scale would be bound to help those at the lower end. Knowledge moves in two directions, and the wisdom, colour, joy and warmth of the South can also be beamed at the speed of light to the rest of the world.

Abdoulaye Wade, President of Senegal

and also in political priorities. One of the main challenges is how to accumulate and systematize information in useful knowledge, through two processes: social learning and social appropriation of knowledge[10].

It is paradoxical that, if ICTs facilitate communication from the global to the local levels and vice versa, they can also broaden the digital gap between those who can participate in the communication process and those that cannot.

ICTs make possible the rise of economies based on knowledge and, therefore, the comparative advantages that come with them create an environment favourable to national and international investment, increasing productivity, democratization of knowledge and information as an instrument for equity, greater social participation, more democratic societies and greater government efficiency and transparency[11]. But they do not represent a panacea. Just as they cannot ensure direct and automatic results, they can also augment technological and economic dependency.

'This unbalanced distribution of scientific activity', adds Annan in the journal *Science*, 'generates serious problems not only for the scientific community in developing countries but also for development itself. It accelerates the disparity between advanced and developing countries, creating social and economic problems at both national and international levels. The idea of two worlds of science is anathema to the scientific spirit. It will require the commitment of scientists and scientific institutions throughout the world to change that portrait to bring the benefits of science to all'.

10. Chaparro, F. (2003) In: *Estado de la Informatización y Fomento a la Integración Digital en Colombia*. September 2003: www.corporacionescenarios.org/documentospreparado.htm
11. *Ibid.*

> *'...poverty is also caused by ignorance. Building knowledge is fighting poverty'*
>
> Adama Samassékou, President, PrepCom–2

Ibero-America feels that the change being stimulated by ICTs could be an opportunity to improve the living conditions of the region's societies and take a step forward through the economic, social and cultural development of countries by involving huge groups of people that have been systematically set aside[12]. Representatives of different governments from the region gathered in Lisbon, Portugal, in June 2001 concluded that it was important to build national and international statistics and indicators in order to impel changes in political agendas and citizenship governance. They considered it imperative for studies on the impact of S&T to be conducted, so that different societies could be better prepared to adapt, create and define their own national realities.

David Dickson warns, 'ICTs have already dramatically transformed the economies – and the social practices on which they are based – in the rich countries of the world. The longer it takes the poor countries to adopt the same practices, the greater the social and economic divide between them and the rich will grow'[13].

Stakeholders in developing countries are aware of the importance of becoming part of the information society. As a reaction to the pressure the new information economies and societies are imposing on them, some countries have taken measures. They have tended to invest more in infrastructure than in capacity-building and local and regional content.

However, to bridge the digital divide, it is urgent for citizens in developing countries not only to have access to ICTs but also to learn the skills they need to use them. Most computer owners in developing countries underuse their computers, Fernando Chaparro[14] lamented recently. Other hardware simply

12. Ana María Prat, CONICYT, Chile. Seminar on the Information Society, and Promotion of Scientific Culture, Public Policies and Follow-up Indicators. Lisboa, Portugal, 25–27 June 2001: www.campus-oei.org/revistactsi/numero1/lisboa.htm
13. www.scidev.net lead article, 6 October 2003.
14. Personal interview with Fernando Chaparro, Director of Digital Nations Colombia, Bogotá, September, 2003.

remains in its original box (no one knows how to use it) or lies around in pieces because people cannot afford to have their computer repaired.

‘At present, the information society is not determined by the new ICTs’, says Pablo Valenti of the Inter-American Development Bank in his paper *Information Society in Latin America and the Caribbean: ICTs and the new Institutional Framework*; ‘it is determined by the new social and economic organization arising from the information society. As such, production, dissemination and use of knowledge have to be transformed into the main opportunity for developing countries to grow[15]. ‘If this does not become a reality, we won’t have any chance of being part of the digital revolution and would, therefore, be reduced to being mere spectators’.

UNESCO’s role in the Summit process

The first round of the World Summit on the Information Society takes place from 10 to 12 December 2003 in Geneva (Switzerland) and the second from 16 to 18 November 2005 in Tunis (Tunisia). Faithful to its mandate, UNESCO is focusing its contribution to the Summit on its areas of competence, namely education, the sciences, culture and communication. These areas, where the impact of ICTs on the activities and product of the human mind is most strongly felt, are the very lifeblood of the information society.

Guided by the United Nations Millennium Declaration and in keeping with international development goals, UNESCO’s contribution to the Summit focuses on four main objectives which each contribute to the themes structuring the preparation of the Summit and its *Declaration of Principles* and *Plan of Action*:

- Agreeing on common principles for the construction of knowledge societies (see Towards knowledge societies, p. 19)
- Promoting the use of ICTs for capacity-building, empowerment, governance and social participation
- Strengthening capacities for scientific research, information sharing and cultural creations, performances and exchanges

15. Valenti, P. (2002) The information society in Latin America and the Caribbean: ICTs and the new institutional framework. In: *Iberoamericana de Ciencia, Tecnología, Sociedad e Innovación*. No.2 January–April 2002: www.campus-oei.org/revistactsi/numero2/valenti.htm

- Enhancing learning opportunities through access to diversified contents and delivery systems.

UNESCO's contribution incorporates the ethical, legal and socio-cultural dimensions of the information society and helps grasp opportunities offered by the ICTs by placing the individual at its centre.

A new culture, based on symbols, codes, models, programmes, formal languages, algorithms, virtual representations, mental landscapes is emerging, implying a need for a new 'information literacy'. Information and knowledge have not only become the principal forces of social transformation. They also hold the promise of alleviating significantly many of the problems confronting human societies – if only the requisite information and expertise were systematically and equitably employed and shared.

There can be no doubt that the emergence of an information society, at very different rates in different parts of the world, arouses great hopes. But these developments have to confront the extreme disparities in access to this new culture and this new literacy between industrial countries and developing countries, as well as within societies themselves.

In this perspective, according to UNESCO, the main challenge the World Summit on the Information Society has to address is the digital divide. This divide accentuates disparities in development, excluding entire groups and countries from the benefits of information and knowledge. This is giving rise to paradoxical situations where those who have the greatest need for them – disadvantaged groups, rural communities, illiterate populations, or even entire countries – do not have access to the tools which would enable them to become fully fledged members of the information society.

A second challenge of the Summit is to work towards ensuring the free flow of, and equitable access to, data, information and best practices across all sectors and disciplines. For free flow to be meaningful, access to information alone will not be enough. Other needs must also be addressed, such as that of fostering knowledge through education and training and by developing contents necessary to translate knowledge and information into assets of empowerment and production.

A third challenge of the Summit is to build an international consensus on newly required norms and principles to respond to emerging ethical challenges and dilemmas of the information society. The trend towards a homogenization of educational, cultural, scientific and communicational activities is disquieting and risks bringing about uniformity of contents and perspective at the expense of the world's creative diversity. The growing commercialization of many spheres previously considered public goods, such as education, culture and information, jeopardizes weaker, economically less powerful but nevertheless equally important segments of the world community. Technological innovations and powerful monitoring mechanisms demand new approaches to the protection of the individual's rights that, at the same time, ensure adequate protection against e-piracy, which severely affects the development of creativity.

This includes studies on specific subjects, such as ICTs and education, cultural diversity and multilingualism, libraries and archives in the information society, media in the information society, the gender issue, access of disabled persons to ICTs, etc.

UNESCO encourages the broadest possible participation by representatives at the highest levels of government, the private sector, civil society and NGOs, decision-makers, professional communities, civil society representatives, bilateral and multilateral partners, and the private sector in a debate on the conditions for the development of an information society for all.

The importance of the Summit, according to UNESCO, is that it will address the broad range of questions concerning the information society and move towards a common vision and understanding of this societal transformation. The goal is to facilitate the effective growth of the information society and help progress towards knowledge.

At the government level, UNESCO involves its Member States in the preparation of the Summit through regional meetings in Europe, Latin America and the Caribbean, Asia Pacific, Africa and the Arab region.

At the non-governmental level, UNESCO organizes consultative meetings with civil society organizations and thematic symposia, and has also been involved in the preparatory committee conferences of the Summit and the regional ones that have already taken place.

The UNESCO Institute for Statistics is currently preparing a statistical report giving a global picture of the current status of ICT usage in education, the sciences, culture and communication. The report will include a cross-section of quality statistical information, as well as key indicators measuring the socio-economic impact of ICTs. It will also provide an overview of key parameters related to the information society: data on personal computers, Internet hosts and users, mobile phone subscribers and the ICT market.

UNESCO is deeply committed to reducing the digital divide and giving all citizens the opportunity to use and master the new ICTs. It shares many of the concerns expressed by the scientific and engineering communities in recent years and has been actively working with these partners to develop recommendations and guidelines for science in the digital era. UNESCO is also trying to narrow the 'scientific divide' by fostering scientific collaboration and capacity-building through North–South and South–South networking. For examples of UNESCO projects, see Innovative Models (p. 73)

Since 1980, the International Programme for the Development of Communication (IPDC) has been assisting developing countries to enhance their communication capacities and improve training in this area. Another key instrument to this end is the intergovernmental Information for all programme established by UNESCO in January 2001 as a platform to help narrow the digital divide through education, the sciences, communication and culture.

Towards knowledge societies[16]

One of UNESCO's main messages to the World Summit on the Information Society is that we need to move towards knowledge societies if we are to bridge the digital divide. In the following interview, UNESCO's Assistant

16. This interview was originally published by UNESCO in *A World of Science*, Vol. 1, No. 4, July 2003.

Director-General for Communication and Information, Abdul Waheed Khan, explains how the concept of 'knowledge societies' differs from that of the 'information society' and why, in a world where 80% of people still lack access to basic telecommunications, knowledge societies are the key to a better tomorrow.

Can information and knowledge contribute to development?

We well know the central role that learning plays in sustainable development and its contribution in particular to poverty reduction and income generation, empowerment and consolidation of democracy, disease prevention and sustainable health and to the protection of the environment.

The access to information and the acquisition of knowledge and skills through education and learning have never been more central than they are today. For me, it is increasingly clear that our ability to cope with rapid changes will become the primary measure of success at both the micro and macro levels.

In this sense, information and knowledge are becoming central to development and to attaining the Millennium Development Goals. We indeed observe that the revolutions brought about by the new technologies, which are increasingly resulting from breakthroughs in the fundamental sciences, are a necessary – but insufficient – condition for the establishment of knowledge societies.

But are these tools really accessible to all?

We know that 80% of the world's population lacks access to basic telecommunications facilities, which are the key infrastructure of the information society and emerging knowledge societies, and that less than 10% has access to the Internet. Access to the information highways and to content, such as development data and information, is still a major problem in many countries. The greatest challenge that all those working in the development field have to face is the digital divide.

It is clear that societies are only equitable if all people, including disadvantaged and marginalized groups such as people with disabilities, indigenous peoples or people living in extreme poverty, but also women and youth, benefit equally from ICTs. They should be enabled to use ICTs for networking, information sharing, creating knowledge resources and developing skills that can help them to live and work in the new digital environment. In our daily work, we encourage and support the use of ICTs as a means of empowering local communities and helping them combat marginalization, poverty and exclusion, especially in the least developed countries, most of which are in Africa.

You are introducing here the term of 'knowledge societies'.
How is this new concept different from that of the 'information society'?

Actually, the two concepts are complementary. Information society is the building block for knowledge societies. Whereas I see the concept of 'information society' as linked to the idea of 'technological innovation', the concept of 'knowledge societies' includes a dimension of social, cultural, economic, political and institutional transformation, and a more pluralistic and developmental perspective.

In my view, the concept of 'knowledge societies' is preferable to that of the 'information society' because it better captures the complexity and dynamism of the changes taking place. As I said before, the knowledge in question is important not only for economic growth but also for empowering and developing all sectors of society. Thus, the role of ICTs extends to human development more generally – and, therefore, to such matters as intellectual co-operation, lifelong learning and basic human values and rights.

What is the role of education in this process?

To my mind, education – both in traditional and in new settings – is the key to creating equitable knowledge societies. I would, however, like to identify two types of linkages between ICTs and education.

The first is the use of education and training, formal and informal, to create IT-literate societies. Enabling all citizens to use ICTs with confidence, in both their personal lives and working environments, is a declared policy in some countries.

The second type of linkage is the use of ICTs within education and training systems to achieve learning goals that do not necessarily have anything to do with ICTs themselves. After some years of mixed results from technology-driven strategies that focused on equipping educational systems with ICTs, we now need to exchange our experiences of education-driven approaches where the educational or training goal determined the use of ICTs rather than the other way around.

I am certain that one conclusion of this exchange will be that age-old methods of educational delivery are unable to meet adequately the growing demand for learning. Initial signs of this incapacity have already led to several innovations: open learning, distance education, flexible learning, distributed learning and e-learning.

In many developing countries, open and distant learning is being mainstreamed as the political desire to increase the provision of learning develops and the economic need to cut the cost of education grows in tandem with participation levels. We are also observing mounting social pressure for democracy and the guarantee for equity and equality of opportunity. At the same time, there is a keenly felt need to improve the relevance and quality of the curricula and to move towards lifelong learning.

Therefore, education – and I am speaking here of both traditional and modern delivery methods – is the condition *sine qua non* of knowledge societies.

Are sciences of a similar crucial importance in this process?

Yes, absolutely. The impact of ICTs in the production, use and dissemination of scientific knowledge is immense. I see many opportunities for them to bridge the science gap, for example by improving networking among scientists locally and internationally, and by providing scientific information and knowledge to decision-makers for better governance.

It is also evident that ICTs are excellent tools for facilitating access by scientists in developing countries to scientific journals, libraries, databases and advanced scientific facilities. Another positive aspect is their potential to improve the collection and analysis of complex scientific data.

However, despite this potential, I am concerned by the danger of a widening scientific knowledge divide. This has immediate consequences for achieving sustainable development and the Millennium Development Goals to which science, technology and innovation can so greatly contribute. This is true not only for fundamental and applied research, but also for education, health, agriculture, technology, economic development and government. In order to achieve this, universities and research institutions worldwide need affordable networking infrastructure, information-processing equipment and training.

There is an essential role for science and scientists to play in building knowledge societies and we must facilitate equitable access to scientific knowledge.

Science in the Summit

Science and technology take the stage

Computers will become so powerful
and there will be so many of them with so much storage
that they will in fact be more powerful,
or as powerful, as a brain and able
to write a programme which is a big brain

Tim Berners-Lee,
inventor of the World Wide Web,
talking to BBC news on 25 September 2003

The first round of the World Summit on the Information Society takes place on 10–12 December 2003 in Geneva, Switzerland. Its benefits, challenges, promises and possible damages concern every human being. The United Nations has stressed the relevance of the presence at the Summit of stakeholders from government, international organizations, business and civil society.

Scientific research being one of the key factors underpinning the development of the information society, the S&T component has been raising attention in discussions. In parallel, UNESCO, ICSU and its Committee on Data for Science and Technology (CODATA), the Third World Academy of Sciences (TWAS), International Council for Scientific and Technical Information (ICSTI), Abdus Salam International Centre for Theoretical Physics (ICTP), World Federation of Engineering Organizations (WFEO) and others have organized a number of meeting on issues of concern to the scientific and engineering communities. Several of these are summarized in the present report (see The message from the S&T Community, p. 33).

Abdus Salam International Centre for Theoretical Physics

Founded in 1964 by Nobel Laureate Abdus Salam, the International Centre for Theoretical Physics in Trieste (Italy) is one of the world's foremost training and research centres for scientists from the developing world.

More than 4000 scientists each year visit the ICTP to take part in research and training related to high-energy physics, mathematics, condensed matter physics, the physics of weather and climate and a host of other fields in which physics and mathematics play a major role. The ICTP runs a number of programes related to ICTs; for examples, see Innovative Models, p. 73)

The Centre operates under a tripartite agreement between the Italian government, UNESCO and the International Atomic Energy Agency (IAEA).

Based on the idea that scientific knowledge is a 'public good'[17], they have concluded that scientific data and information should be made as widely available and affordable as possible, since the greater the number of those able to share them, the greater the positive effects and returns for society. There are, however, still strong pleas coming from both the commercial sector and sympathetic governments to strengthen intellectual property rights and copyright regimes even further.

If we go back to 1641, less than two centuries after the invention of the modern printing press, Samuel Hartlib, exiled in Great Britain, wrote, 'the art of printing will extend knowledge and, if lay people are conscious of their rights and freedom, they will never be governed oppressively'[18]. What is at stake now is the equitable accessibility and feasibility of scientific knowledge and information through the web by every citizen in the world. The

17. R. Stephen Berry defines a public good as a good whose value does not diminish with use. Public goods produced from science typically increase in value with use. That science is a public good implies that any institution that funds research for the purpose of producing public goods carries the responsibility for seeing that the results of the research are disseminated. Dissemination is necessary for the public goods to emerge from research. Because the public goods from research amplify with increasing use, the benefits of dissemination typically produce a marginal return that may increase rapidly beyond the initial investment in that dissemination.
18. Briggs, A. and Burke P. (2002) *A Social History of the Media. From Gutenberg to Internet.*

development of new ICTs opens up unparalleled opportunities to ensure universal and equitable access to scientific data and information and to enhance the global knowledge pool. However, excessive privatization and commercialization of scientific data and information is proving a serious threat to the realization of these opportunities for societal benefit. This latter trend is undermining the traditional sharing ethos of science. It is shrinking the public domain and threatening open access to global public goods with a consequential loss of opportunity at both the national and international levels[19].

> *We paid the price for not taking part in the Industrial Revolution of the late eighteenth century because we did not have the opportunity to see what was taking place in Europe. Now we see that ICTs have become an indispensable tool. This time, we should not miss out on this technological revolution.*
>
> F. K. A. Allotey
> Ghanaian scholar

While there has been a strong focus on new commercial opportunities using digitalized information and on increased intellectual property rights, comparatively little attention has been devoted to the importance of maintaining open access to the source of upstream scientific data and information produced in the public domain for the benefit of all downstream users, or to the imperative of balancing public and the private interests. (For further discussion on this topic, see What future for open science? p. 38).

19. Summary Report on the International Symposium on Open Access and the Public Domain in Digital Data and Information for Science, 10–11 March 2003, jointly organized by UNESCO, ICSU, CODATA, the US National Academies and ICSTI, and the Workshop on Science in the Information Society, 12 March 2003, jointly organized by UNESCO, ICSU and CODATA.

Putting science on the Summit agenda

The debates that flourished between 2000 and 2003 (see The message from the S&T community, p. 33) on the digital divide convinced the S&T community of the importance of integrating the scientific perspective into the World Summit on the Information Society. Yet as late as June 2003 the draft *Declaration of Principles* and *Plan of Action* were still almost totally bereft of any reference to science.

One of the issues scientists – and other groups participating in the Summit – will be pushing for is that of an open software system in which computer programmes are free of cost or at least more affordable, instead of 'paying Microsoft, the software giant', notes Diego Malpede, Director of Science and Technology at TWAS (see Why UNESCO is encouraging free software, p. 29). 'The digital divide' he goes on to say, 'including disparities in access to telephone networks and the Internet, to computers and electronics, is a symptom of a scientific divide as well. In spite of technological progress, this gap continues to grow; it is evident, for example, in the rising prices of scientific publications'.

In a leading article published in *Science*[20], Professor Jane Lubchenko, ICSU President, and Shuichi Iwata, CODATA President, write, 'although no one appears to be strongly opposed to the principle of open and equitable access to scientific data and knowledge, that value can easily be relegated to a secondary position relative to short-term commercial interests. Hence, it is crucial that the scientific community continue to promote the societal benefit of widely shared scientific knowledge... Our goal is to ensure that science continues to feature strongly in the final drafts of the formal summit documents expected to emerge from that meeting'.

By late 2003, things had improved to the point where CERN was able to declare to the press with some satisfaction that 'representatives from the international scientific community were finally able to convince the United Nations to take their contributions into account in the preparatory process for the World Summit on the Information Society in December'.

20. Lubchenko, J.; Iwata, S. (2003) Science in the information society. *Science* 301: 5639. (September, p. 1443).

Why UNESCO is encouraging free software

In 2001, UNESCO began lending its support to the Free Software and Open Source movements. In the software computer science field, these movements play a key role in extending and disseminating knowledge. The UNESCO Free Software Portal was published in November of the same year. It gives access to local and remote documents which are reference works for these movements, as well as to websites hosting the most popular and useful open source/free software packages in UNESCO fields of competence.

The portal links up to software in astronomy, chemistry and biology, mapping tools and physics. Scientists will find there UNESCO's Virtual Laboratory Toolkit containing information and free software tools for creating a virtual laboratory. The Toolkit covers person–to–person and person–to–equipment communication to enable scientists to create or participate in a virtual laboratory.

There are also links to virtual libraries, such as the free African Digital Library for residents of Africa with its 8,000 full-text e-books[21]. UNESCO is also currently distributing through the portal and on CD-ROM a trilingual (English–French–Spanish) version of the open source Greenstone Digital Library software. Greenstone is produced by the New Zealand Digital Library Project at the University of Waikato and is being developed and distributed in co-operation with UNESCO and the NGO Human Info (Belgium).

UNESCO freeware[22] information processing tools are espousing the open source development model; these include WinIDAMS[23] for the validation, manipulation and statistical analysis of data and CDS/ISIS[24] for the storage and retrieval of information.

So why is the 'open source' movement so important for knowledge-building? Historically, companies or developers of proprietary software have not made the source code (i.e. programme) available to users, but only the final executable module. With Free Open Source Software, each user can also access the source code and is granted autonomy rights which enable him or her to run, copy, distribute, study and change the software without having to ask permission from, or make fiscal payments to, any external group or person.

For further information, go to the UNESCO Free Software portal: www.unesco.org/webworld/portal_freesoft

21. www.africaeducation.org/adl/
22. Freeware is distributed for free but without the source code, whereas open source is not necessarily free but the source code is distributed with the executable module.
23. www.unesco.org/idams
24 www.unesco.org/isis

> **The International Council for Science**
>
> ICSU is an umbrella organization comprising 101 multidisciplinary national members, associates and observers and 27 international, single-discipline scientific unions. ICSU's membership provides a wide spectrum of scientific expertise, enabling members to address major international, interdisciplinary issues which none could handle alone.

In order to enrich the debate on how science can narrow the digital divide, UNESCO, CERN, TWAS and ICSU are co-organizing a conference on The Role of Science in the Information Society (RSIS) at CERN Headquarters in Geneva, the Summit host city, on 8 and 9 December. The conference will immediately precede the World Summit on the Information Society itself in the same city.

Sessions at CERN will include talks on the history of the Internet and the World Wide Web; how science has both contributed to, and benefited from, these advances; and ways in which ICTs can revolutionize education, health care, environmental stewardship, economic development and enabling technologies. Distinguished speakers will include Tim Berners-Lee, inventor of the World Wide Web, Ismail Serageldin, Director-General of the Library of Alexandria, and President Ion Iliescu of Romania.

The meeting will issue a declaration recognizing the contributions of science to electronic information sharing and an action plan to ensure continued development of ICTs and their application to science and society. These documents will feed into the Summit itself. 'Science underpins much of the information society and will be the motor behind its continued development,' says Robert Eisenstein, President of the Santa Fe Institute and member of the RSIS executive committee. 'This meeting provides a unique opportunity for scientists of all disciplines to share ideas with governmental representatives and form a common vision of the future.'

The conference's conclusions will feed both into the Summit itself and into the UNESCO roundtable being held as a Summit event on 11 December on Science, the Information Society and the Millennium Goals. Ministers from both North and South responsible for science will be

And science created the Web

The World Wide Web was invented in 1990 at the world's largest particle physics centre, the European Organisation for Nuclear Research, (CERN), to enable scientists from different countries to work together. By making the World Wide Web freely available to the global community, CERN revolutionized the world's communications landscape. The World Wide Web has gone on to help break down barriers around the world and democratize the flow of information.

Tim Berners-Lee developed Hypertext Markup Language (HTML), which allows movement from one site to another on the World Wide Web, and the Hypertext Transfer Protocol (HTTP), permitting communication among different computers connected to the Internet.

He is also behind the Universal Resource Localisers (URL), a system for assigning unique addresses to every web page, and the first version of the World Wide Web itself.

The millions of Internet users around the world recognize all of these initials but most do not know who Berners-Lee is. As inventor, he not only renounced intellectual property rights over his creations but also strives to ensure that the Internet remains open to everyone and the property of none.

A few words about CERN. The Laboratory is supported by 20 European Member States. Established in 1954 under the auspices of UNESCO, CERN has become the world's leading Laboratory for the study of the fundamental constituents of matter. Physicists from more than 50 countries around the world participate in the experiments at CERN's facilities, for a total of around 6500 users. www.cern.ch

invited at the roundtable to say how they would implement an agenda for action to ensure universal and equitable access to scientific knowledge in the information society. A major focus will be on the theme close to UNESCO's heart of bridging the digital divide – by promoting universal access to scientific knowledge, improving education and training and resolving a number of policy issues in scientific information. Debate will focus on several themes, including the dependence of sustainable development upon open and equitable access to scientific knowledge and the role that ICTs play.

Third World Academy of Sciences

TWAS was founded in Italy in 1983 by a distinguished group of scientists from the South under the leadership of the late Nobel laureate Abdus Salam (www.ictp.trieste.it/ProfSalam/index.html) of Pakistan. The principal aim of TWAS is to promote scientific capacity and excellence for sustainable development in the South. About 80% of TWAS's membership is made up of Fellows representing some 60 countries in the South.

At the invitation of the Swiss government, the World Federation of Engineering Organisations (WFEO) is organizing a Summit event[25] on Engineering the Knowledge Society on 11 and 12 December in Geneva, in collaboration with the International Federation for Information Processing, Swiss Academy of Engineering Sciences and Swiss Federation of Information Processing Societies. The event will stress what needs to be done to achieve a human-centred, inclusive and sustainable knowledge society.

WFEO has been actively involved in the Summit process since the outset. It organized the World Engineering Congress on the Digital Divide in Tunis in October 2003, which attracted more than 160 S&T organizations from around the world and culminated in the Carthage declaration (see p. 64).

Another science event will be the exhibition organized by CERN and the United Nations Office for Projects Service (UNOPS) on behalf of the world's scientific community. Entitled SIS-Forum@ICT4D (Science and Information Society Forum at the ICT4D), the exhibition will be displayed in Palexpo, Geneva, from 9 to 13 December. It will consist of digital demonstrations and presentations of projects and activities, all focusing on science's leading role in driving the development of the Information Society. Exhibits will dramatize features of science that foster ICT innovation.

25. http://ict.satw.ch/

The message from the S&T community

Background

ICTs offer unprecedented opportunities to support science education and training programmes that exploit and enhance global knowledge yet can be tailored to local needs. An ever-increasing amount of science and technology information is freely available. Yet, without education and training on how to access and utilize it efficiently and effectively, the potential benefits for society as a whole will not be realized.

Jane Lubchenko
President of ICSU

Scientific research and technology drive today's economies and serve as twin pillars of progress for advances in knowledge for all humankind. At the same time, ICTs are central to scientific research itself: ICTs enable scientists to perform fundamental and applied research, build partnerships and scientific international consortia, conduct experiments, collate data, co-ordinate laboratory activities and communicate their findings to their peers and the public. The digital world in which we live is not only a product of science but also a fundamental force for shaping the scientific research agenda and determining how the future of scientific knowledge will unfold and be utilized.

ICTs have the capacity to increase accessibility to scientific knowledge worldwide. The digital world offers novel opportunities for involving scientists in developing countries in scientific endeavours of their choice around the globe, provided some very basic ICT tools are at their disposal.

Despite this potential, the knowledge divide appears to be widening. Increasing inequalities in access to ICTs are reducing opportunities for individuals and institutions to develop and use scientific knowledge that could help foster innovation, facilitate efficient decision-making and support education and training. The digital divide addressed by the World Summit on the Information Society shares many of the same characteristics of the scientific divide, defined by the enormous gap in scientific research, innovation and diffusion of technology.

In order for these inequalities to be reduced and for sustainable development and the Millennium Development Goals to be achieved, science, technology and innovation will have to play a crucial role, maximizing the possibilities and benefits of ICTs in the areas of fundamental and applied research, education, health, agriculture, technology, economic development and government.

Therefore, ensuring equitable access to scientific knowledge and to software tools for analyzing and disseminating this information is essential, as well as making affordable networking infrastructures available, information-processing equipment, software and training to universities and research institutions worldwide[26].

How can the world share information and knowledge under the same conditions? How do we bridge the digital divide with regard to the production of knowledge? ICTs, their effects on the exchange of S&T information and the new social and economic scenarios penned by ICTs are issues the entire world is concerned about.

The meetings being held in December 2003 on The Role of Science in the Information Society and Engineering the Knowledge Society are part of a process of reflection that goes back a number of years. This process has involved a large number of academic and S&T institutions, as well as international bodies. A hotbed of discussion, these meetings have involved participants from the public and private sectors, from North and South. The following section gives an overview of the issues at stake and the messages the S&T community wishes to convey to the different stakeholders in science.

26. Drawn from comments and inputs from the scientific community on the draft *Declaration* and *Action Plan* (CERN, UNESCO and ICSU, in co-operation with TWAS and ICPT).

The role of science in developing knowledge societies

The intrinsic value and spin-offs of fundamental science

Luciano Maiani, Director-General of the European Organisation for Nuclear Research (CERN), had three messages for the ministers attending the Ministerial Roundtable at UNESCO in October 2003 on the theme of Towards Knowledge Societies. 'The fundamental sciences were a crucial driving force for innovation in our societies', he said. They 'had contributed in an essential way to the development of modern ICTs, first with the World Wide Web and now with the Data GRID and had the potential for integrating developing countries into an ICT network, thus contributing to filling in the digital divide'.

Taking examples from the science he is most familiar with, elementary particle physics, Maiani focused first on the intrinsic value of fundamental research then on the spin-off benefits that accrue as a direct result of the technological demands our science makes. (It goes without saying that arguments could also be taken from astronomy, genomics, the study of the brain or all other sciences that try to explore the world around us, its relations to ourselves, in brief, sciences which try to understand the way nature works in all its manifestations.)

'Thanks to fundamental research in physics, all the matter we can see in the Universe is made up from a handful of elementary particles', Maiani told the ministers. 'I can tell you almost all about the way these particles interact among themselves. However, I can also tell you that what we can see in the Universe accounts for only about 5% of what we know to be there. About the rest, we know almost nothing.

That we occupy such a small fraction of our Universe is fascinating and extending our knowledge is by itself good reason for pursuing fundamental research', he went on. 'With the Particle Accelerator today in construction at CERN, the Large Hadron Collider, we will be taking the first steps towards find out what the remaining 95% is and how it is related to the familiar 5% that we inhabit.

But fundamental research has brought more than just knowledge. The classic argument for fundamental research as a powerful driving force for innovation is that all major technological advances in history have come through curiosity driven projects with no immediate practical goal in mind.

Applied research and development (R&D) might make you a better candle but it will never bring you the electric light bulb. Similarly, applied R&D might perfect the thermo ionic valve but it will never stumble across quantum mechanics, essential to the way transistors work.

Fifty years ago, there were just a few particle accelerators in the world, used as tools of fundamental research. Today, there are thousands of accelerators in the world, and they are far more likely to be found in applied science, in hospitals or in factories than in fundamental research laboratories.

A most important application of accelerators is synchrotron radiation. It is used to study the structure of small things, like viruses, or to study how high-performance plastics behave. Over half the world's particle accelerators are used in medicine.

Many forms of diagnosis have recourse to radiopharmaceuticals produced using a particle accelerator. About 20 million people each year undergo diagnosis using radiopharmaceuticals.

Many forms of medical imaging depend on particle detector technology first developed for nuclear and particle physics. The forerunners of the detectors used in many PET scanners were developed for particle physics experiments in the USA and at CERN.

In therapy too, particle accelerators have a role to play. Radiotherapy is a common treatment applied to over half of all cancer patients. It is a form of biological surgery where the scalpel is replaced by a tiny particle capable of sterilizing malignant cells by cutting out the DNA that causes them to multiply.

The most common form of radiotherapy uses X-rays or electrons from a linear accelerator. In the 1960s, neutrons came on the scene. In the most recent developments, proton and heavy-ion accelerators are being adopted for hadron-therapy, as this emerging field is known. The advantage of the latter particles is that they deposit all their energy in the same place, making hadron-therapy suitable for treating tumors near to delicate organs where precision is vital.

ICTs for science and science for ICTs

The best-known spin-off from fundamental research is without a doubt the World Wide Web. Invented at CERN in 1990 in response to the growing communications needs of the world's particle physics community, the Web was put in the public domain in 1994 and has gone on to revolutionize the way we share information and do business. Its value to the world's economy would have paid for all the fundamental science done last century many times over.

Freedom of expression and freedom of opinion, the right to seek, receive and impart information and ideas regardless of frontiers (as enshrined in Article 19 and 29 of the *Universal Declaration of Human Rights*) are the necessary premise of the information society. In building such an information society, the ability for all of to access and contribute information, ideas and knowledge is essential. The Web was developed along these principles, which form the basis of fundamental research and the basis of the Web's success.

A major exciting development in ICTs is the concept of a global information-processing GRID. This computing GRID is being driven by the need to process the vast amount of data to be produced at CERN by the Large Hadron Collider and to be made available worldwide. Other sciences will profit from the GRID, such as climate research or genetics.

The GRID will harness the power of computers networked across the world to improve society – to improve health, medicine and education, and to share the benefits of technology worldwide. A first global prototype of the GRID is already working, connecting CERN to its allied laboratories.

Scientists working in wide international collaborations are committed to developing new tools, such as the GRID, with potential benefits for all countries on both sides of the digital divide, in the areas of science, education, medicine, technology and economic development. This is made possible by the very nature of fundamental science, which fosters openness, free communication and collaboration beyond national, ethnic and racial borders'.

How to obtain the maximum benefit from new developments

To obtain the maximum possible benefit from these revolutionary developments, four conditions need to be fulfilled, according to Maiani:

- that fundamental scientific information be made freely available;
- that the software tools for disseminating this information also be made freely available;
- that networking infrastructure for distributing this information be established worldwide;
- that training of people and the equipment to use this information be provided in the host nations.

In conclusion, Maiani states that 'fulfilling these conditions worldwide is a formidable challenge which will require a close collaboration between science, industry and governments. CERN urges that these four topics be given suitable prominence in the discussions at the World Summit on the Information Society in December 2003'.

What future for open science? [27]

CERN's decision to place a little-known piece of software called the World Wide Web in the public domain opened the floodgates to Web development around the world. Ten years on, the Web is one of the most spectacular examples of the fruit of publicly funded science in the public domain today. Yet it might never have happened. A growing temptation to privatize or commercialize government-funded, public-interest science is imposing restrictions of all kinds on open (i.e. public) science. Why is this happening and what are the consequences for science? And how do we preserve and promote access to open science without unduly restricting commercial opportunities and the moral rights of authors?

These core questions were addressed by an international symposium on 10–11 March 2003 at UNESCO Headquarters in Paris. The meeting on Open Access and the Public Domain in Digital Data and Information for

27. This text is based on an article originally published by UNESCO in *A World of Science*, Vol. No. 4, July 2003.

Science was co-organized by UNESCO, ICSU, CODATA, the US National Academy of Sciences and ICSTI. The following account, which was prepared by UNESCO, expresses the meeting's central concerns. The symposium was followed on 12 March by a workshop convened to draft *Agenda for Action for Science in the Information Society* (see p. 47).

The Web has become an indispensable feature of the modern communications landscape – but it might have been a very different story. Web inventor Tim Berners-Lee explains, 'CERN's decision to make the Web foundations and protocols available on a royalty-free basis, without additional impediments, was crucial to the Web's existence. Without this commitment, the enormous individual and corporate investment in Web technology simply would never have happened and we wouldn't have the Web today'.

The economic spin-offs have been giddying. The Web has generated billions of dollars in e-commerce earnings over the past decade, mostly in the North. It has even spawned a new stock exchange, the Nasdaq. Many of the economic spin-offs are the last link in a chain beginning with scientific information and data, and ending in innovative products and services.

E-networking the world's universities and research institutes

In addition to being a formidable communication tool, the Internet is an extremely rich vehicle of information and data for education, research and, ultimately, innovation with its economic returns.

The isolation of scientific communities in the Third World can, in part, be broken through unbridled access to scientific information and data, and through international collaboration. North–South and South–South networking is a powerful tool for capacity-building and development. Many such examples already exist. Following the devastation caused by Hurricane Mitch in Honduras and Nicaragua and the earthquake in El Salvador, for example, the three countries have set up Disaster Information Centres. UNESCO's environmental programmes in the hydrological, oceanographic, ecological and geological sciences rely heavily on both types of networking[28] (for details of examples listed here, see Innovative models, p. 73).

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28. IHP, IOC, MAB, IGCP: www.unesco.org/science

Virtual research laboratories, libraries and university campuses are spreading. UNESCO for example is spearheading the Avicenna Virtual Campus involving 15 countries of the Mediterranean basin and Europe[29] and the Virtual University of Science and Technology launched with ASEAN[30], which is currently expanding into virtual R&D with local engineering institutes and private companies. UNESCO is also promoting open access to data and information through projects like SANGIS and ODINAFRICA, in rigorous conformity with international conventions on intellectual property.[31]

In the USA, the prestigious Massachusetts Institute of Technology[32] announced in 2002 that it would be posting 2000 courses and related contents on the Internet free of charge for all the world's higher education institutions and students. MIT is willing to provide information on how to adapt these courses, in response to concerns from people like Abdulaye Diakité of Guinea's Conakry University that 'some laboratory experiments done at MIT won't be possible in universities in developing countries'.

Good news indeed – but universities and research institutes in the South will only be able to take full advantage of these various programmes if they are equipped with affordable and reliable high-speed Internet connections.

Growing pressures on open science

Digital information and data in the 'public domain' may be accessed freely without infringing any legal rights. But the meeting in March 2003 noted that, insidiously, restrictions were eating away at open science. And that data and information produced by government-funded, public-interest research were increasingly being privatized or commercialized. The meeting also observed that the growing difficulty for authors to protect their work from uncontrolled access was leading to calls for tighter intellectual property protection of information on the Internet.

29. http://avicenna.unesco.org
30. In Jakarta: s.hill@unesco.org
31. www.unesco.org/culture/copyrightbulletin
32. http://ocw.mit.edu

What would the consequences have been for global health research if the human genome project had been commercialized? Initiated by the US government in the late 1980s, the project was threatened by a corporate rival in 1998. At that point, the Wellcome Trust[33], a UK charity, teamed up with the US government, increasing massively its investment in the project so that its own Sanger Institute could decode one-third of the three billion letters that make up 'the code of life'. Today, the sequences – completed in April 2003 – are freely available to the world's scientific community.

So where do you draw the line? Robin Cowan of the University of Maastricht in the Netherlands notes that, 'there is a tension and all of the economic literature on intellectual property rights is about resolving that tension or finding the optimal balance … so that people can use the knowledge and [not] the expression of it'.

This tension is illustrated by a current Chinese dilemma. In May, the e-journal SciDev.Net reported the Chinese State Intellectual Property Office as having advised researchers to patent their SARS-related research, following media reports that some Canadian, US and Hong Kong research institutes were preparing to apply for local and international patents on research that included sequencing of the SARS genome and a diagnostic test for SARS. China has ploughed millions of US dollars into SARS-related projects. Although many Chinese researchers are refusing to apply for patents, citing concerns that it might impede co-operation, Lin Jianning, director of the state-owned China Southern Pharmaceutical Institute, warns that, 'without sufficient patent protection, the Chinese successes could become sources of profit for international pharmaceutical firms'. Sri Lankan-born virologist Malik Peiris and his team at the University of Hong Kong were the first to isolate the agent causing SARS, in mid-March.

Cowan points to the paradox by which easy access to knowledge fosters innovation through providing data and information for research, even as intellectual property rights limit the spread of this new knowledge until it falls into the public domain at the expiration of the patent.

33. www.wellcome.ac.uk/

The breaking of a taboo

Funding for open science has been shrinking in the North for the past twenty years. ‘The Bayh–Dole Act in the USA, which took effect in 1981, broke a taboo’, Cowan recalls. ‘It was one of the first government measures to begin eroding open science’. It was intended to facilitate technology transfer from the academic to business worlds by enabling federal-funded universities to license their new inventions to businesses which then manufactured the end-products. ‘In the USA’, he notes, ‘this has led to an explosion in the number of university patents’. Universities in Europe and in some of the larger countries of the South have sought to emulate the Bayh–Dole approach by commercializing public research results in the university sector.

Treating public research as a commodity can have perverse effects. Peter Weiss of the US National Weather Service, comments that, when one government research institute has to pay a sister institute to recover scientific information or data using the same taxpayer funding, it makes for ‘false economics’.

Preferential pricing for paying publications

All information production and dissemination has a cost. But for poorer countries, this cost is frequently prohibitively expensive if borne by the user. The question is, how to do you tailor the cost to the user to make sure information remains affordable? Preferential pricing is one solution. Many commercial publishers are interested in providing their works electronically under preferential conditions for science and education, particularly to users in developing countries, provided their copyright is strictly respected.

Like private publishers, professional societies are searching for an optimum balance between open access and financial viability. Some professional societies and other groups have embraced the open access model, although the majority still tend towards a more protective approach.

Numerous international programmes are now showing that affordable access to commercial publications in developing countries is possible (see Innovative models, p. 73). Many publishers also make their publications available at no cost to developing countries, such as the *British Medical Journal*.

UNESCO is looking carefully at ways of promoting this type of initiative, for example through frameworks of voluntary permission by which publishers and other rights-holders could assign specific rights to users in developing countries, either definitively or on a limited time basis.

Borders in cyberspace

Researchers from the South regularly run into what Weiss calls ‘borders in cyberspace’ when trying to access information and data in the North. The prices charged by some governments are far beyond the means of poor countries and the data often come with onerous restrictions on use. This naturally deals a blow to public-interest research that may have the potential to generate knowledge of national, regional or even global importance, such as in the field of meteorology.

Weiss notes that US government agencies are not only forbidden to charge more than cost to disseminate scientific information but are even urged to take advantage of private, academic and other channels to do so. The reason for this, Weiss insists, is ‘based on a hard-headed economic understanding that government information is a valuable national resource, just like gas, coal or water, and an input to the economic process. The economic benefits to society are maximized when government information is available in a timely and equitable manner to all. For this reason, he foretells, ‘the USA does not have a sui generis database protection regime, nor is it likely to have any such regime in the near future’.

A step closer to owning facts

For its part, the European Union has had a database protection regime since March 1996. ‘The implications of the European Directive on the Legal Protection of Databases from a science and technology perspective’, notes CODATA, ‘are that it creates an unprecedented, absolute exclusive property right for the contents of databases that contradicts the underlying premise of classical intellectual property law which says no-one should own factual data as such; it conveys an exclusive property right to the content of all databases even if these do not qualify for copyright protection. This right lasts for an initial period of 15 years and can be extended indefinitely whenever updates or substantial investments are added’.

According to CODATA, 'even though the European Directive permits fair use[34] of data for research and education as an exception, the exception is narrowly drawn and not all Member States have enacted a fair-use provision into their domestic law'.

One aspect stressed by Thomas Dreier from the University of Karlsruhe in Germany is that 'whereas, within copyright law, patent applications from researchers in France, Germany or Italy are subject to the same conditions by the European Patent Office, the European Directive has been interpreted by national laws in different ways. The Directive has thus not done away with national discrepancies. This', he notes, 'is leading to court battles'.

In 2002, the European Commission initiated a review of the Directive, to which ICSU and CODATA responded. The report was submitted to the European Commission in 2003. The next step will be for any recommendations for modification to be submitted to the European Parliament.

'Original database' is not an easy term to define. Alan Story of the University of Kent Law School in the UK cites the example of his own country where the definition of an 'original database' is so broad that even street directories and television schedules are being protected, despite their being simple compilations!

Intellectual property not working for South

The development of special limitations, restrictions, negotiated agreements and cost-recovery policies is making it more difficult for some scientists to gain access to data and information than others. Most threatened by this trend of course are the scientific communities in developing countries and countries in transition.

34. The fair use clause makes provisions for use of copyrighted material in the public interest, such as free reproduction for the purposes of research or education, etc. It was these provisions which made the public library possible. In the digital world, the fair use clause may act against the legitimate interests of rights-holders, given the ease with which digital information can be reproduced.

As Clemente Forero-Pineda of the Universities of Andes and Rosario in Colombia points out, ‘While the 1994 Trade-related aspects of Intellectual Property (TRIPS) agreement protects original databases, the protection of non-original databases is granted in the European Union, some northern European countries and Mexico. The main concern is that even information in the public domain could be simply reorganized and included in proprietary databases…. Preliminary analyses for Latin American countries show that most non-original databases are produced elsewhere[35]’. Forero-Pineda goes on to say that, ‘Were this trend towards stronger legal protection of databases to prosper, … the role of researchers from developing countries in global science would diminish in relative terms as a consequence of the narrower availability of scientific information’. WIPO’s Standing Committee on Copyright and Related Rights is currently discussing the establishment of international protection for non-original databases.

Under TRIPS, computer software is protected as a literary work as defined by the main international instrument in the field of copyright, the Berne Convention for the Protection of Literary and Artistic Works. Both agreements presume a proprietary model of software.

Many aid agencies and governments in the North pride themselves on helping developing countries gain wider access to data and information. In that case, notes Story, they ‘should cease privileging intellectual property protected proprietary software in their computer aid programmes to poor countries’. Story cites the Co-ordinator of the Leland initiative run under the USAid programme, which ships PCs equipped with Microsoft products to poorer countries’, as saying that ‘on balance, we are for the cheapest and most affordable approach which would be open source.’ According to Story, countries in the South are rapidly expanding use of free and open source software because they cannot afford proprietary systems (see Why UNESCO is encouraging free software, p. 29).

Countries wishing to become members of the World Trade Organization must also become signatories to TRIPS which, in turn, requires that they must also abide by all of the key provisions of the Berne

35. According to Alan Story, Latin America and the Caribbean accounted for only an estimated 0.2% of all existing databases in the world in 2001.

Convention. All three are ‘minimum rights’ agreements, ‘which means that all signatory countries must provide protection up to a certain minimum level’ (50 years from the death of the database author in the case of TRIPS).

‘This means’, explains Story, ‘that a country of the South could not decide that, because of its strong economic reliance on agriculture and the damage caused to its agricultural sector by insects and other pests, copyright protection on insect-related databases and encryption of such databases would be forbidden, even if the aim of such a ban were to promote scientific research. Nor is there any public health exemption that would allow access to data on HIV/AIDS for researchers for example. Although database legislation states that the protection ‘does not extend to the data...itself’, the encryption of databases can prevent any access whatsoever to the data and hence operates to prevent lawful uses of that data, such as “fair dealing” or library/archive exemptions’.

One aspect of the 1996 WIPO Copyright Treaty is the absence of a maximum term or duration of protection for copyrighted material, making it quite legal for countries to make the protection permanent.

Story ironizes that overprotection of intellectual property rights is not considered as trade-distorting, despite the evidence to the contrary. ‘In the name of non-discrimination, countries of the South are assimilated to countries of the North, despite the fact that their needs and means are different’.

‘The one shoe fits all law breeds inequality rather than the reverse’, concludes Story. ‘We need to challenge the presumptions of intellectual property because, overall, intellectual property does not work for the benefit of countries of the South in the current conjuncture’.

Acting to strengthen the public domain: an *Agenda for Action*

The need to strengthen the public domain and ensure equitable access to scientific data and information emerged very clearly from the symposium described above on Open Access and the Public Domain in Digital Data and Information for Science.

Agenda for Action for Science in the Information Society

1. Ensure that all universities and research institutions have affordable and reliable high-speed Internet connections to support their critical role in information and knowledge production, education and training.
2. Promote sustainable capacity-building and education initiatives to ensure that all countries can benefit from the new opportunities offered by ICTs for the production and sharing of scientific information and data.
3. Ensure that any legislation on database protection guarantees full and open access to data created with public funding. In addition, restrictions on proprietary data should be designed to maximize availability for academic research and teaching purposes.
4. Promote interoperability principles and metadata standards to facilitate co-operation and effective use of collected information and data.
5. Provide long-term support for the systematic collection, preservation and dissemination of essential digital data in all countries.
6. Promote electronic publishing, differential pricing schemes and appropriate open source initiatives to make scientific information broadly accessible.
7. Encourage initiatives to increase scientific literacy and awareness of how to interpret Web-based scientific information.
8. Support urgently needed research on the use of ICTs in key areas, such as geographical information systems and telemedicine, and on the socio-economic value of public domain information and open access systems.
9. Recognize the important role for science in developing and implementing the new governance mechanisms that are necessary in the information society.

Following on immediately from the symposium on 12 March, UNESCO and ICSU convened a workshop of leading scientists from around the world and representatives of international organizations to draft an *Agenda for Action for Science in the Information Society*. The aim was to alert governments to the concerns of the scientific community in the run-up to the World Summit on the Information Society.

In their *Agenda for Action*, scientists convey a strong message to governments. By October 2003, this same message had already been endorsed by several international scientific academies, unions and organizations.

Scientific data for society

Scientific data are the quantitative information used to communicate the results of science. As such, they are a relevant kind of information that should flow through the ICTs. Experiments, observations, theory, models and simulation all generate scientific data. In the past, data usually were presented as tables of numbers. Today, scientific data are most often stored in databases and involve numbers, text, images, diagrams, pictures and equations.

The primary feature differentiating scientific data from scientific information is that data are the results of science, not a description of what was done, how it was done and why it was done. To have a full understanding of science, full information is required. To use scientific results to do new science requires the data themselves.

Today, our ability to generate data is unprecedented. New instruments, such as the Hubble Space Observatory, make detailed observations on an immense scale possible. Electronics and computers simplify experimental operations and make repeat measurements much easier. Computers, application software and advances in numerical algorithms and modelling techniques allow for calculations of virtually every physical phenomenon. Fortunately, information technology provides us with the capability to capture, store, manage and use these large volumes of data. Indeed, during the

The Committee on Data for Science and Technology

ICSU's Committee on Data for Science and Technology (CODATA) works to improve the quality, reliability, management and accessibility of data of importance to all fields of science and technology. It is a resource providing scientists and engineers with access to international data activities for increased awareness, direct co-operation and new knowledge.

CODATA is concerned with all types of data resulting from experimental measurements, observations and calculations in every field of science and technology, including the physical sciences, biology, geology, astronomy, engineering, environmental science, ecology and others. Particular emphasis is given to data management problems common to different disciplines and to data used outside the field in which they were generated. (www.codata.org) last twenty years, every area of science has become dependent on scientific data activities to capture and exploit breakthroughs in their disciplines and almost every scientist has become a data practitioner (creating and using databases).

A less obvious but perhaps more important reason for the growing importance of scientific data is the evolving multidisciplinary nature of R&D. Advances in one discipline become critical for research in another area and data are the mechanism to quantitatively make those linkages. For example, a medical researcher will design a potential gene therapy using molecular biology-based data. Environmental modelling requires basic chemical reaction rate and solubility data.

Society in general uses the results of science in many ways. Society takes advantage of a better understanding of our physical world to improve quality of life. Society uses research results to solve problems. Society accepts technological advances based on an understanding of their impact on our physical world. Society uses science to control the future based on accurate predictions and informed decisions. In these and other ways, society uses scientific results, usually irrespective of the original intent of the scientific investigation.

Because data are a primary mechanism for communicating scientific results, scientific data are important to society. Health, safety, social, environmental, security and other issues are illuminated by these data, and for society to take advantage of them, data quality accessibility and utility are important.

Data quality is perhaps of most significance for making decisions. Understanding data quality is very hard for non-scientists. The growing importance of scientific data to society makes it mandatory for the scientific community to make data quality more understandable to society at large.

Data accessibility is equally important because, if data are not accessible, it is as if they did not exist. Today, it seems unimaginable for data not to be accessible. The Internet, World Wide Web, search engines, PCs on everyone's desk and Web pages by the millions appear to have solved the accessibility problem. That is not the case. Substantial economic barriers are

Example: The change to environment-friendly refrigerants

In the 1980s, scientific evidence accumulated on the negative impact of chlorofluorohydrocarbons on various regions of the Earth's atmosphere. These CFCs were prevalent in modern household and industrial products. However, scientific data were clearly and effectively presented not only to scientist and engineers, but also to society at large. Society's acceptance of these data was instrumental in obtaining the many trade-offs that were required to change to new propellants and refrigerants.

blocking society's access to data. Companies wish to exploit data for profit motives. Nations consider that protective intellectual property regimes foster economic development. Data vendors want to make money from providing data access. And large amounts of existing data are being ignored because of the costs associated with computerizing older paper data collections. Society and science must work together to make sure that investments in science are not constrained by lack of accessibility. Data themselves are rarely profitable; their usage is. Economic rewards should not be based on data scarcity but rather on innovation in data exploitation.

Data management is also of concern. What do you do with a terabyte of data? What do you do with data from ten different data sources, each in a different format and perhaps in different languages? How do you take advantage of incomplete data sets, or compare one data set with another when the two sets have different amounts and kinds of data? These issues are of concern to scientists themselves and are of greater concern to non-expert users. Tools such as standards, visualization and analysis, aimed at non-expert users, will be critical to society taking advantage of scientific data. It is the responsibility of science to help society manage and use data.

The great importance of scientific data for society should be clear. One need only list numerous issues that society must address – for example, the use of genetically modified organisms, energy shortages, HIV, global climate change – to realize that clear communication and widespread availability of high-quality scientific data is critical for informed decisions. The World Summit on the Information Society offers a remarkable opportunity to educate scientists and society about scientific data and their importance.

The database dilemma

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. Synthesizing 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.

ICSU, CODATA and their member organizations have become increasingly concerned about proposals to the World Intellectual Property Organization (WIPO) 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 proposes a core set of principles drafted in June 2000 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 has to be struck. A healthy research community is essential 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 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[36].

The principles are:

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

36. www.codata.org/codata/data_access/principles.html

the world. Science is a critical public investment in our future, a resource with extraordinary dividends.

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.

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.

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.

The interests of database owners must be balanced with society's need for an open exchange of ideas. Given the substantial investment in data collection and its importance to society, it is equally vital that data be used to the maximum extent possible. Data 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.

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.

An OECD report, *Promoting Access to Public Research Data for Scientific Economic and Social Development*, 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 infrastructures, 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
5. *Cultural and behavioural issues:* Appropriate reward structures are a necessary component for promoting data access and sharing practices.

Preserving scientific data

In November 2002, ICSTI stated that, despite the growing efforts of many of the varied stakeholders involved in generating, organizing and providing access to scientific information and data, much of it in digital form was still at risk of being lost to future generations.

The same can be said of the digital data collected over the past forty years. Data from the Viking mission to Mars is just one example of expensively gathered, important information that has already been lost.

Data-handling principles

The example of the Integrated Global Observing Strategy

In 2000, the Integrated Global Observing Strategy (IGOS) partners adopted a set of principles for data and information systems and services. These principles apply to all IGOS activities, including those of the 'Theme Teams', as they are known: the Ocean Theme Team, Geohazards Theme Team, Global Carbon Theme Team, Atmospheric Chemistry Theme Team and Global Water Cycle Theme Team. A Sub-theme Team on Coral Reefs is currently being put together as the first component of an ultimate Coastal Theme.

The 14 IGOS partners are free to complement or interpret the principles as they see fit within the contours of their own individual data policies, which are sometimes legally binding. The 11 principles apply to both short-term and long-term observation.

The first principle underlines the need for a 'continuing commitment… by participating national governments and international bodies to data management systems and services to ensure the establishment, maintenance, validation, description, accessibility, reliability and distribution of high-quality data'. These bodies include the Committee on Earth Observation Satellites[37], WMO and the Global Climate Observing System and World Climate Research Programme, UNESCO and the Global Ocean Observing System hosted by the IOC, FAO and the Global Terrestrial Observing System, UNEP, ICSU and the International Geosphere–Biosphere Programme.

Another principle states that the 'full and open sharing and exchange of data and products for all users in a timely fashion is a fundamental objective'. The Partners also consider that 'metadata should be assembled and maintained so that they are easily and fully accessible to users.' These metadata include information on calibration, long-term quality assessments and guidance for locating and obtaining the data records. For the full list of principles, go to: www.igospartners.org

More needs to be done as a matter of urgency to put systematic structures in place to ensure the long-term availability of the records of science to all who need them, bearing in mind the special difficulties of developing countries in accessing digital publications.

37. UNESCO has been a member of the CEOS since November 2002.

A comprehensive scientific digital archive is likely to be a complex network resulting from discipline-specific, institutional, national and international initiatives. Further work is required to define archiving policies, to be clear about where responsibilities lie and to ensure that a properly supported, funded and sustainable infrastructure is put in place which can stand the test of time.

The issue of digital archiving is essentially a matter of scientific and public policy which should be of concern to all scientists, especially those in a position to influence policy.

For ICSTI, there are four levels of problems:
The Formal Literature: The importance of preserving the formal, refereed published literature of science is well understood and accepted. But for digital publications, many issues remain unsolved:

- Is it merely the contents or also its form and presentation which need archiving?
- How is authenticity to be guaranteed?
- Which version(s) should be preserved?
- How are adequate indexing procedures to be arranged?
- Are the links, so important in many electronic information services, to be maintained and, if so, how?
- How are copyright, data protection and other intellectual property issues to be addressed in ways that enable repositories to maintain perpetual archives and provide appropriate access to users?

Archives, libraries and publishers need advice from the scientific community on these issues.

The Informal Literature
As well as the formal refereed literature of science, much is recorded and reported outside the formal process, increasingly on the Web. In the traditional print world, this ‘grey literature’ has often proved important for science and has thus been collected and preserved by research libraries. Given the variety and ever-changing electronic publishing channels and platforms, collecting this material in the digital age poses special problems. It is not even clear if harvesting this material from the Web is legal, given that the copyright usually rests with the author or publisher.

Personal Archives
At another level, the personal archives of scientists have often been of interest and value to science. How can scientists approach their work in the electronic environment in such ways that future generations can effectively and economically study their work? What guidance needs to be given to scientists and how can scientists be incited to follow such guidelines?

Data
Last but not least, how do we preserve scientific data? Modern science generates and uses huge amounts of quality data. In the atmospheric sciences alone, selected satellite and radar systems are generating hundreds of terabytes of data. Substantial investments are being made in data collection and analysis. If action is not taken to preserve this data, it will be lost, yet much of it (e.g. observational data), by its very nature, cannot ever be collected again. The value of scientific data is enduring and meaningful access to it must be preserved. The computer programmes used for analyzing data may also need to be preserved.

For the past six years, ICSTI has sought to increase awareness among the scientific, publishing, library, archive and data communities of the critical and urgent need for action to ensure long-term access to the records of science. With the active co-operation and support of other international bodies, including UNESCO, ICSU, ICSU Press and CODATA, it has brought together key stakeholders in conferences aimed at promoting better understanding of the many issues involved, facilitating the transfer of knowledge between sectors and strengthening the necessary collaboration between scientists, publishers, archivists, librarians and data managers.

Considerable progress has been made:

- The importance of archiving science was recognized by the World Conference on Science organized by UNESCO and ICSU in Budapest (Hungary) in 1999.
- An Open Archival Information System (OAIS) Reference Model has been approved as an ISO standard. This model, which owes much to the work on data archiving from the space sciences, is already being widely adopted as a starting point in digital efforts.
- Several publishers, large and small, commercial and not-for-profit, have developed archiving policies and, in many countries, publishers

and national libraries are collaborating on either the voluntary or legal deposit of electronic publications.

A large volume of research has been undertaken, sponsored by intergovernmental and governmental agencies and by foundations, to develop standards, investigate the technical infrastructure requirements for archiving, build collaborative structures, help understand user requirements and to set out the necessary attributes and responsibilities of trusted repositories.

These collective efforts of archivists, librarians, publishers and data managers have resulted in a better understanding of the techniques for preservation and of the standards that need to be applied for economy, interoperability and access. These efforts will no doubt continue and grow. They are essential but not sufficient to achieve the goal of a well-ordered, adequately funded, sustainable network of scientific data and information archives which can adequately maintain and provide future access to the records of science.

The voice of science and scientists must be put behind these efforts. Therefore, it is imperative to:

1. undertake for each of the scientific disciplines a high-level audit of digital preservation policies and practices that are now in place (ICSTI welcomes the lead taken by the International Union of Pure and Applied Physics (IUPAP) in proposing a system to monitor electronic publishing and preservation practices in pure and applied physics.)
2. work with the other key stakeholders in defining user requirements for archives
3. formulate and disseminate policies on the preservation of the research that funding agencies sponsor.

There are significant technical, administrative, and economic issues associated with the longer-term availability of scientific data and information and these constitute important elements in establishing policies in the area of open access. ICSTI recommends that all scientists undertaking research bear in mind the importance of the long-term preservation of the data and information they generate and adopt such standards as are recommended to facilitate this.

Electronic publishing in science

In his concluding remarks to a UNESCO/ICSU meeting on Electronic Publishing in Science on 19–23 February 2001, Sir Roger Elliott, then Chairman of ICSU Press, noted that there remained no consensus on the most appropriate economic model for electronic journals even if many were the subject of experimentation. He was sceptical as to the likelihood of a single specific system evolving in the short term and stated that 'there may well be a case for continuing different methods of funding'.

What the meeting did make clear was the need for the academic and research community 'to take a greater interest and hold over the dissemination process of their work and their behaviour, that of their employers and the funding agencies. 'It is important for them to understand the legal framework which is being developed as traditional copyright laws are modified for the electronic environment. Some of these new laws have been unfriendly to the scientific endeavour because they are framed with different commercial imperatives in mind. This is another area where the academic and research community needs to engage more effectively in the debate'.

The meeting was organized at UNESCO Headquarters in Paris in co-operation with CODATA, ICSTI and the International Federation of Library Associations (IFLA). It produced the following guidelines for electronic publishing in science, which target to varying degrees all stakeholders in the scientific information chain: governments, funding agencies, scientific organizations, publishers, librarians and individual scientists themselves.

I. General Issues

1. At this stage in the evolution of electronic publishing, serious experimentation is needed. Models should be developed that allow for the continued expansion and enhancement of scholarly communication. Governments and others involved must avoid setting unduly restrictive rules that make such experimentation more difficult.
2. The wide availability of electronic journals and ease of access for browsing and searching is essential.

3. Publishers and librarians should collaborate to use the new medium to obtain information that allows them to improve the management of scientific publications and facilities for scientific use.
4. ICSU and UNESCO should recognize the value of broad meetings of this type for enhancing the scientific information chain. In the light of rapid changes in technology, such meetings might take place at shorter intervals than the five years between the first and second Conferences.

II. Electronic Publishing Issues

Archiving

1. The digital archiving of electronic publications is essential in order for unique results not to be lost to posterity. A cross-disciplinary body should be created to propose guidelines that assure such archiving at an (inter)national level, including the possible involvement of trusted third parties.

Peer review

2. Peer review is essential to ensure the quality of scientific information. A standardized approach across all disciplines for peer review would be inappropriate. There should be further study of alternative approaches to peer review (including more open variants) in order to assess the impact of such processes and associated behaviour. The results of this experimentation should be widely communicated.

Preprints

3. When preprint servers are used as part of the continuum of communication, an ongoing bibliographic record of the publication history must be maintained in association with the document. Authors should be educated in the importance of providing such information, but the responsibility for maintaining this record requires an organizational framework.
4. When citing preprints, authors should be encouraged to identify the version referred to. The bibliographic record (see recommendation II.3 above) should provide a reference to any subsequent published version.

5. When technically feasible, publicly available and particularly peer-reviewed versions of articles should be authenticated to guarantee that they are the correct version.

Citation linking

6. Rights holders and publishers should facilitate linking for all references. It is desirable that systems for reference linking be bi-directional, interoperable, and open to all authors and publishers.

Ethical standards

7. Ethical considerations in publishing are of considerable importance. When the code of conduct of scientific and professional societies has been apparently violated, it is incumbent on the journal editor to follow up the case and take appropriate action.

III. Economic Issues

1. In order to maximize the dissemination of high-quality scientific information worldwide, it is essential that a continually improving level of infrastructure (hardware, bandwidth, etc.) be in place.
2. Funding agencies should take some responsibility for funding the publication of the results of the research they have supported.
3. Experimentation to test transitional methods of funding the publication should be encouraged and the results of such experimentation widely communicated.
4. Differential pricing using the minimal marginal costs of the Web should be encouraged in relation to the ability to pay, while pricing and terms of use should be simplified as far as possible.
5. Scholarly information should be tax-neutral with respect to the medium used, and there should be more consistency at an (inter)national level.

IV. Initiatives and developments in developing and transitional countries

1. ICSU, UNESCO and all those concerned with the dissemination of scientific information should take action to facilitate information

access to developing and transitional country scientists through improved infrastructure, including the rapid setting-up of Internet facilities, connectivity and networking, where needed.
2. Equally, the skills of scientists, publishers and librarians in the publishing chain should be enhanced, in terms of writing, editing, publishing, disseminating and marketing, and archiving.
3. National, regional and international co-operation and partnership should be fostered through the sharing of resources, knowledge and experience, and the creation of consortia and alliances, to achieve more affordable economic models.
4. An enabling policy environment should be encouraged at the national level, including dialogue with local communities, and participatory initiatives at regional and international levels should be promoted.
5. A global commitment to support and sustain these initiatives needs to be secured.

V. Legal issues

1. The principles of copyright, together with its traditional balances and exceptions, should be maintained in the electronic environment.
2. Science advances through access to, and the unfettered use of, factual information. Scientific, non-commercial use should not be constrained by legal restrictions on the use of data or information derived from databases.
3. For scientific databases, there is often only a sole supplier, with the potential to block markets, or not serve them adequately. National and intergovernmental organizations should therefore promote a policy to assure the availability of database information at reasonable cost.
4. Additionally, if the rights holder cannot assure long-term archiving of the content of scientific databases, this policy should be extended in order that appropriate arrangements can be made for long-term preservation.
5. ICSU should establish a policy of prompt, full and open access to scientific data and information acquired within ICSU-sponsored programmes. Such a policy would be consistent with the ICSU

principle of the universality of science and could parallel the existing ICSU statement on the Free Circulation of Scientists.

6. ICSU and UNESCO should endorse a policy of prompt, full and open availability of publicly funded data. Such a policy would enhance research effectiveness and output, as well as benefiting society as a whole through a better-informed public and economic growth.

VI. Issues relating to public involvement in scientific matters

Within their particular domains, all stakeholders in the scientific information chain, including ICSU, UNESCO, IFLA, learned societies and individual groups of scientists, should assume greater responsibility for designing ways to help readers distinguish credible from questionable scientific information on the World Wide Web.

The Carthage Declaration on the Digital Divide

The information society increases our dependency on technology:
that is why establishing a suitable framework will be of key importance.
The Internet should play a humanising role,
creating a more democratic and equitable society on a global scale.

Ion Iliescu
President of Romania

It is widely recognized that engineers have played, and continue to play, a crucial role in the development of the information society. Their role is to translate science into practice and provide the platform where needs meet practice. Thanks to the combined effects of science, engineering and technology, our world has witnessed tremendous changes over the past few decades.

The World Summit on the Information Society has been recognized as a challenge for the engineering community. The adopted *Declaration* and *Plan of Action* will provide the guidelines for the future of the information society. Engineers, as key actors of technological development, have identified many issues that should be included within the framework of the Summit.

During the preparatory process for the Summit's first phase, the S&T family, represented by the World Federation of Engineering Organizations (WFEO) in the Civil Society Bureau, was actively involved in a dialogue between stakeholders and governments. The statement delivered hereafter on behalf of the S&T community highlights the role of engineers in the process of developing the information society, stressing that engineers are responsible for transfering and developing the new technology that will afford access to information to all nations – and not only developed ones.

One of the most important isssues related to the development of the information society is that of achieving broad, low-cost connectivity and access to information. The gap between info-poor and info-rich countries remains enormous. Access to Internet in some regions is almost imposible because of the high cost of infrastructure. It is engineers who will be responsible for solving this problem by providing low-cost solutions.

Within the framework of the Summit process, WFEO organized the World Engineering Congress on the Digital Divide in Tunis (Tunisia) from 14 to 16 October 2003. The Congress attracted more than 160 organizations active in science and technology. The scientific programme was made up of five thematic sessions:

- Human capital, society of knowledge, new pedagogies
- Strategies for building the information society
- Legal and ethical considerations for a harmonious, dynamic and sustainable development
- Practical solutions for bridging the digital divide: the contribution of engineers and scientists
- Infrastructure, networks and connectivity.

The Congress emphasized the role of engineering and technology in the development of ICTs and the information society. It also called for a closer partnership in technology transfer and capacity-building for the development of infrastructure and connectivity to bridge the digital divide and create digital solidarity. A high-profile event, the Congress was organized under the patronage of the President of Tunisia and opened by the Prime Minister, with government ministers chairing all five thematic sessions.

Representatives of the world's engineering community recommended:

- Mobilizing human potential at the international level to elaborate ways for the developing countries to benefit from the technological achievements in developed countries and at the same time reduce the gap between info-rich and info-poor countries.
- Stressing the role of the engineering community in capacity building in developing countries.
- Increasing awareness of the importance of engineers' participation in the decision making process.
- Promoting engineering education for youth.

The Carthage Declaration[38] adopted at the Congress makes concrete proposals for inclusion in the *Plan of Action* to be adopted by the World Summit on the Information Society. The *Declaration* also supports the creation of a world solidarity fund. The engineering community asks that this

38. www.coi-tn.org/wfeo-cic/declaration_en.htm

fund serve as a base for a digital solidarity fund which would finance projects such as the search for technical solutions permitting the spread of access to a high-speed information network at an affordable cost.

Carthage Declaration of the World Federation of Engineering Organizations on the Digital Divide

We, the representatives of the engineering and technology community gathered in Tunis from 14 to 16 October 2003 as part of the preparatory process for the World Summit on the Information Society by the World Federation of Engineering Organizations, with the active participation of representatives from:

- the Tunisian and Swiss governments
- the International Telecommunications Union
- UNESCO, the World Bank, the United Nations Economic Commissions for Africa and Western Asia, the International Satellite Organization, the Technical Park of Trieste, the World Innovation Foundation

have agreed upon the following principles:

- ICTs offer enormous potential to generate and distribute wealth and contribute to the United Nations Millennium Development Goals and World Summit for Sustainable Development's *Plan of Action*.
- It is essential that the digital gap between the 'info rich' and the 'info poor' be closed. The digital gap contributes to the widening of the economic gap and aggravates exclusion and marginalization.
- We express our strong concerns regarding the growing disparities in network access. The disparities extend beyond the North–South gap and exist within countries, between generations and different social classes.
- We are convinced of the potential importance of the World Summit on the Information Society as a forum for debating the issues and advancing viable solutions by engaging the public/private sector in partnerships.
- We emphasize the proven ability of innovation and R&D to find solutions to problems generated by the new information society.
- The development of technology must not be guided solely by profit; science, engineering and technology must serve the needs of people.

- We affirm our determination to work actively as partners to reduce the digital divide. Engineers are on the front lines, their fundamental role is to adapt science for the benefit of people, in particular the poor.
- We affirm our vision of the information society: a society which is open and inclusive promotes the diffusion of knowledge and facilitates the sharing of information; a society that values the development of human beings above all else; a society that respects cultural and linguistic diversity.
- We call on governments to agree to commit resources to creating a vehicle for financing low-cost, high-speed network access that enables the sharing of knowledge and technologies meeting basic human needs for water, food, energy and health. In this perspective, we congratulate them for the creation of the World Solidarity Fund adopted by the 57th Session of the General Assembly of the United Nations (N°A/RES57/265).

The Ministers' Message

Background

Highlighting the role of knowledge societies in 'achieving sustainability and future prosperity', more than 50 ministers and vice-ministers attending a two-day Ministerial Roundtable at UNESCO on the theme of Towards Knowledge Societies on 9–10 October 2003 made a large number of recommendations. One of these concerns the creation of a funding mechanism to help bridge the digital divide which deprives the populations of developing countries and the marginalized in developed countries of access to ICT. The ministers proposed setting-up a digital solidarity fund to augment national resources. This recommendation was endorsed by the engineering community at its own meeting in Tunis on 14–16 October 2003.

In the Communiqué issued at the end of the Roundtable, the ministers called on governments to 'reassess their development priorities in order to make the necessary investment in building knowledge societies' which 'entail many issues other than technology and connectivity.' Building and applying knowledge for human development, states the Communiqué, implies respect for a set of principles and priorities: freedom of expression; universal access to information and knowledge; respect for human dignity and cultural and linguistic diversity; quality education for all; investment in science and technology; and understanding and inclusion of indigenous knowledge systems.

The Ministerial Communiqué UNESCO, 9–10 October 2003

1. We, the ministers participating at the Roundtable organized by UNESCO at this crucial time in the preparations for the World Summit on the Information Society, arrived at the following common position.

2. Our Governments are committed to improving the quality of life of our citizens and the economic strength of our societies and to achieving an equitable and peaceful global community. The building of knowledge societies is an essential approach to achieving these objectives and paves the way to humanizing the process of globalization'.
3. Knowledge societies are about capabilities to identify, produce, process, transform, disseminate and use information to build and apply knowledge for human development. They require an empowering social vision which encompasses plurality, inclusion, solidarity and participation.
4. Universal access to information and knowledge cannot be obtained without the building of the relevant technological infrastructure. Information and communication technology (ICT) is a major tool for building knowledge societies, and these societies also entail many issues other than technology and connectivity.
5. Knowledge societies must be based on universally recognized human rights, respect for privacy and human dignity, and solidarity of and among peoples. They must reflect high ethical and professional standards.
6. Building knowledge societies implies a commitment to the principles of democracy, transparency, accountability and good governance. This process must engage, and recognize the interdependency of, governments, the private sector and civil society. Lack of access to knowledge engenders marginalized and disadvantaged populations and hinders the participation of these populations in decision-making and the development process.
7. We are very concerned about growing inequalities in infrastructure development and in the access to, and use of, technologies. Our goal is to transform the digital divide into digital opportunity through digital solidarity.
8. Building knowledge societies is essential for achieving sustainability and future prosperity. Governments should thus reassess their development priorities in order to make the necessary investments in building knowledge societies.
9. We urge the international community to help the developing countries to build their capacity so that they can achieve self-reliance as soon as possible. To achieve this objective, we need to pay

particular attention to the identification of possible mechanisms for the funding of this effort, including the setting-up of a digital solidarity fund to augment national resources.

10. The following principles and parameters are essential for the development of equitable knowledge societies:
    - Freedom of expression
    - Universal access to information and knowledge
    - Respect for human dignity and cultural and linguistic diversity
    - Quality education for all
    - Investment in science and technology
    - Understanding and inclusion of indigenous knowledge systems.

Freedom of expression

11. The free flow of information is the fundamental premise of knowledge societies. In a knowledge society, each individual will have more freedom and greater possibilities for self-realization, while respecting beliefs and ethics. Knowledge societies encourage openness and dialogue and appreciate wisdom, communication and cooperation. They must be based on the principle of freedom of expression as guaranteed in Article 19 of the *Universal Declaration of Human Rights:* 'Everyone has the right to freedom of opinion and expression; this right includes freedom to hold opinions without interference and to seek, receive and impart information and ideas through any media regardless of frontiers'.
12. Freedom of the press must be upheld and promoted to ensure that all media, traditional as well as new, can fulfil their role in the building of knowledge societies. Media professionals in particular, as key agents in materializing and ensuring freedom of expression, should be afforded an environment which is conducive to the exercise of their profession.

Universal access to information and knowledge

13. No society can claim to be a genuine knowledge society if access to knowledge and information is denied to a segment of the population. We therefore affirm the need for universal access to information and knowledge. By access we imply: infrastructure and connectivity; content; affordability; information literacy;

know-how for use and development; education; and, the free flow of opinions and ideas.

14. Much of the world's population does not have access to any ICT, whether radio, telephone or the Internet. As traditional media are still an important brick in the building of knowledge societies, countries must accord a high priority both to the development of traditional media and to the putting in place of modern ICT infrastructure which is accessible to all.
15. It is essential to ensure affordable access to a wide range of content. This includes provision of data, publications, artistic works, radio and TV programs, and computer programmes including open source software, support for access gateways such as libraries, and formulation of national policies to promote publicly accessible information, particularly in the public domain.
16. We also affirm the need to develop measures to create cyber-security which do not infringe on the free flow of ideas, opinions and information.

Respect for human dignity and cultural and linguistic diversity

17. Cultural diversity is the common heritage of humankind. Understanding and respect for other cultures is a prerequisite for building inclusive and participatory knowledge societies. Plurality and diversity are central to our understanding of knowledge and society. Knowledge societies must enable citizens to access and create information and knowledge in their own languages and within their own cultural frameworks. We are committed to facilitating the participation of all cultural and linguistic groups in the building of knowledge societies.
18. Nurturing, preserving and diffusing tangible as well as intangible cultural heritage, both nationally and internationally, is an integral element in the shaping of knowledge societies. To this end, appropriate cultural policies and public–private partnerships should promote the production of local creative content and its wide accessibility in electronic form. In particular, ICT should be used by creators and cultural institutions and industries to preserve and promote minor languages and cultures.
19. In the light of the opportunities and challenges of knowledge societies, culture and artistic expression and exchange should be

promoted. Libraries, archives and museums, and the professions which permit them to function, are at the heart of knowledge societies and should be strongly supported and promoted within national policies.

20. We underline the necessity for determined action to fight against forgery and piracy of cultural goods as an essential element of efforts to encourage healthy and diverse cultural creation.
21. In building knowledge societies, we must maintain and promote an equitable balance between the rights of creators, owners and users of intellectual property, and the public interest.

Quality education for all

22. Access to education is a fundamental right, as well as a tool for combating illiteracy, marginalization, poverty and exclusion. ICT provides vast opportunities to effectively and affordably provide quality education for all.
23. It is only through quality education that the profound changes which we seek in our societies can be brought about. The opportunity to acquire an information culture which encourages critical evaluation of information should be an essential part of education at all levels.
24. We need to rethink and redesign our educational systems and processes to meet the challenge of the knowledge societies – to find new ways of looking at information and knowledge according to which we have a right to acquire and a duty to share.
25. Considering the rapid advances in ICT and its application in development, regular upgrading of knowledge and skills of information and ICT professionals is imperative.
26. Teachers are the pivotal force for achieving these goals and should be involved from the beginning in educational reform. We recognize that sustained effort will be required.

Science and technology in knowledge societies

27. There is a well established relationship between a country's scientific capability and its prosperity. Science and technology are the wellspring for creation of knowledge. Therefore, the public sector, as well as the private sector, in all countries should invest in building science and technology capacities, including research

and development, science education and electronic networks for science and research. Affordable access to scientific and technological content, such as publications and databases, is a critical development priority. There is also a need to identify and preserve traditional knowledge, to apply ICT to make it available to all and to establish appropriate links with modern science.

Indigenous knowledge systems

28. Indigenous knowledge systems constitute an important component of emerging knowledge societies. Every effort should be made to identify, understand, digitize and mainstream indigenous systems to enable them to be universally accessible and to contribute to the development of knowledge societies.

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29. We appeal to heads of state and government to participate personally in the World Summit on the Information Society and commit ourselves to:
    - pursuing earnestly the broad objectives of this Communiqué at the Summit, and
    - keeping in mind the broad objectives of this Communiqué while formulating national policies.
30. We call on the Director-General of UNESCO to:
    - bring this Communiqué to the attention of the World Summit on the Information Society and ensure the relevant follow-up;
    - facilitate further initiatives for a better understanding of the impact of knowledge societies on efforts to build a peaceful and prosperous global community; and
    - explore appropriate mechanisms for technical and financial assistance to the developing countries in the building of knowledge societies.

Innovative models

Background

Both Jerome Reichman from Duke University Law School in the USA and Paul Uhlir from the US National Academies argue for reinforcing and recreating, by voluntary means, a public space in which the traditional sharing ethos of science can be preserved and insulated from commodity-bias trends[39].

A number of successful initiatives around the world to promote the production of, and open access to, S&T data and information were presented by participants in the March 2003 meeting at UNESCO. Examples of these and other initiatives are given hereafter[40].

- *In the environmental sector*

Geospatial information for development
A new endeavour set up in India, the Spatial Data Infrastructures (SDI) encompasses the policies, organizational remits, data, technologies, standards, delivery mechanisms and financial and human resources necessary to ensure the availability of, and access, to spatial data. It is visualized as a virtual network of standardized, spatial databases of varieties of spatial information enabling easy access and major support to decision-making and sustainable economic growth.

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39. www.codata.org/archives/2003/03march/03march-abst.htm
40. Many of these examples were presented to the meeting held at UNESCO Headquarters on 10-11 March 2003 and figure in four brochures subsequently published by ICSU, one of the five organizers.

UNESCO Network
for Application of Remote Sensing
for Sustainable Development in Africa

This recent project applies remote sensing to the management of ecosystems and freshwater resources in Sub-Saharan Africa. The nine participating countries are Benin, Botswana, Côte d'Ivoire, Equatorial Guinea, Guinea, Mozambique, Niger, Senegal and South Africa. The network is made up of regional African bodies like the West Africa Regional Centre for Training in Aerospace Surveys, in Nigeria. It counts among its partners a number of European institutions including the European Space Agency, as well as the Brazilian Space Agency and Indian Space Research Organization, together with several United Nations bodies.

TerraLib
(www.terralib.org)

TerraLib is an open-source for geographical information systems (GIS) libraries in Brazil enabling quick development of custom-built applications for spatial data analysis. This project shows that pursuing a 'learning by doing' approach, combined with substantial investment in local human resources, is the key to the successful deployment of advanced information technology in developing nations.

SANGIS
(www.cifeg.org/sangis/sangisbase.htm)

The Southeast Asian Network for a Geological Information System (SANGIS) is a UNESCO project involving national geological surveys and governments which simplifies the exchange of data, both within and beyond Southeast Asia, via Internet, for more effective socio-economic and environmental planning. The participating countries are: Cambodia, China, Indonesia, Japan, Korea (Rep. of), Lao PDR, Malaysia, Papua New Guinea, The Philippines, Singapore, Thailand and Vietnam. The French International Centre for Training and Exchange in Geoscience (*Centre international pour la formation et les échanges en geosciences*) is UNESCO's partner in developing the architecture of the system and in organizing training courses in data handling and other topics.

Information and Communication Services for Sustainable Development (Infocom) (www.dea.met.gov.na/programmes/infocom/soer.htm)

This programme from Namibia, with support from Finland, promotes environmentally sustainable development practices in Namibia by providing pertinent and appropriate environmental information to policy, planning and decision-making processes and to all relevant stakeholders through an effective Environmental Information System (EIS). It is a communication mechanism to disseminate geographical information.

Ocean Data and Information Network for Africa (ODINAFRICA) (www.odinafrica.net)

This UNESCO project assists the 20 participating countries in Africa to establish and operate National Oceanographic Data Centres and develop a wide range of data and information products that cover both the individual countries and Africa as a whole. All data and information are made available freely and openly, in full accordance with the Data Policy of the Intergovernmental Oceanographic Commission's Oceanographic Data and Information Exchange programme (IODE). ODINAFRICA is also supported by the Government of Flanders (Belgium). The ODINAFRICA website is co-ordinated by the Kenya Marine and Fisheries Research Institute in Mombasa but maintained jointly by all partners. The project publishes a Newsletter, *WINDOW*.

- *In the public health sector*

The Ptolemy Project (www.utoronto.ca/ois/ptolemy.htm)

This is a research partnership between the Office of International Surgery at the University of Toronto and members of the Association of Surgeons of East Africa (ASEA). It is a simple model linking an existing end-user community with a large university library. It combines the provision of access to high-quality electronic health information with a process to evaluate its impact on participants. Ptolemy delivers useful, timely and relevant contents to surgeons in Africa, and it has made an immediate and positive impact on their work. It is a simple, practical and replicable model for bridging the digital divide in order to build clinical, teaching and research capacity in East Africa.

Health information for disaster preparedness in Latin America

The National Library of Medicine (NLM) and the Pan-American Health Organisation (PAHO) have developed a project to rebuild and improve the health information infrastructure in Honduras, Nicaragua and El Salvador, by helping these countries develop a system for collecting and disseminating health information related to disasters. These three countries have established Disaster Information Centres designed to enable health professionals, government agencies and NGOs to access vital previously unavailable information and, therefore, improve disaster prevention activities.

Bioline International and the Journal of Postgraduate Medicine
(see under electronic publishing, p. 76)

HealthMap (www.who.int/emc/healthmap/HealthMap.pdf)
HealthMap is an interactive information and mapping system developed by the World Health Organization which strengthens data collection, management and dissemination to support public health activities and decision-making. It provides an interface between data and maps, resulting in geographic information systems (GIS) playing a vital role in the detection of, and response to, health problems.

- *In electronic publishing*

Over the last few years, researchers, publishers and policymakers around the world have been debating the concept of making scholarly literature 'open access', allowing any Internet user to read, download, print, copy, search and redistribute published articles or to use their contents in other legal ways, such as in databases and textbooks. Because the reader neither has to pay for access to the information nor receive permission to use it, open access publishing may have a tremendous impact on those who do not have access to scholarly literature, such as researchers in developing countries. There are two directions of science communication to consider with respect to these researchers: being able to access international journals and being able to promote their own local journals on an international scale[41].

41. The Scientific Research Society, Sigma Xi International Newsletter. Vol.2 No. 3., October 2003: www.sigmaxi.org/programmes/international/newsletter.shtml

The Internet and data transfer and storage technologies have greatly accelerated collection, storage and dissemination of scientific data and information over the last decade. There have been, however, some significant developments, especially in industrial countries, as regards ICTs, legislation on intellectual property rights and methods for commercializing scientific information. These changes have put economic, legal and technological restrictions on full and open access to scientific information and data. They have created a tension between the traditional interest in a thriving public domain – in which publicly funded research data is openly and universally available – and the commercial interest in acquisition, ownership, licensing,and sale of scientific data and information. A growing number of institutional initiatives aim to provide developing countries with low-cost access to on-line scientific information:

- **The Programme for the Enhancement of Research Information (PERI)**, operated by the International Network for the Availability of Scientific Publications (itself created by UNESCO and ICSU in 1991), provides low-cost access to more than 8000 full-text on-line journals and databases. PERI's on-line services improve access to local research results, as well as locally facilitated training in Internet use and publishing skills for researchers, publishers, editors, and librarians. (www.inasp.info/peri/)
- **Through the Health InterNetwork Access to Research Initiative (HINARI)**, an initiative of the World Health Organization, accredited public institutions can take advantage of free or very low-cost access to more than 2000 leading biomedical journals. (www.healthinternetwork.org)
- **The electronic Journals Delivery Service (eJDS) Programme**, run by TWAS and the ICTP, distributes scientific articles via e-mail to scientists working in institutions in developing countries, where insufficient bandwidth makes it difficult to download material from the Internet. (www.ejds.org/)
- **The African Journals OnLine (AJOL)**, managed by the International Network for the Availability of Scientific Publications, provides Internet access to the contents of more than 50 journals published in Africa, backed by web links to electronic versions of articles (where available) and a delivery service for document photocopies. (www.inasp.info/ajol/)

- **The Open Archives Initiative** is a forum to discuss and develop common Web protocols for e-print archives. It also promotes their global acceptance and accessibility across physical, organizational and disciplinary boundaries. These protocols ensure that various e-print archives can interact, thereby making it possible to access any paper from any computer, as if the material were held in one virtual public library. (www.openarchives.org)
- **The Global Online Research in Agriculture (AGORA)** is a new initiative that has been launched to provide researchers and academics in some of the world's poorest countries with free or low-cost access to scientific literature in food, nutrition, agriculture and related biological, environmental and social sciences. AGORA will provide access to more than 400 key journals in these fields, with the long-term goal of increasing the quality and effectiveness of agricultural research and training in low-income countries. The initiative comes from the United Nations Food and Agricultural Organization (FAO), Cornell University Mann Library, Rockefeller Foundation, the UK Department for International Development and the US Agency for International Development.
- **The Public Library of Science (PLoS)** is a non-profit organization of scientists and physicians committed to making the world's scientific and medical literature a freely available public resource. PLoS is an Internet and electronic publishing group that allows the creation of public libraries of science containing the full text and data of any published research article, available free of charge to anyone anywhere in the world. It has immediate unrestricted access to scientific ideas, methods, results and conclusions that will speed the progress of science and medicine, and will more directly bring the benefits of research to the public. To realize this potential, a new business model for scientific publishing is required that treats the costs of publication as the final integral step of the funding of a research project. PLoS is working with scientists, their societies, funding agencies and other publishers to pursue the goal of ensuring an open-access home for every published article and to develop tools to make the literature useful to scientists and the public. www.publiclibraryofscience.org/
- **Bioline International and the *Journal of Postgraduate Medicine*** has been providing since 1993 electronic publishing and distribution

services for publishers of biomedical journals from developing countries seeking to increase the visibility, accessibility and impact of their publications. In 2002, the *Journal of Postgraduate Medicine* (JPGM), a quarterly biomedical publication of Staff Society of Seth G.S. Medical College and K.E.M. hospital in Mumbai, India, joined BI as an open access journal. The collaboration of BI and JPGM sets an example for the ways in which journals from developing countries can benefit from low-cost shared technology and extend accessibility to their contents.

- **The Encyclopedia of Life Support Systems (EOLSS)** is a virtual library on the health, maintenance and future of life on planet Earth. It focuses on sustainable development in all its aspects – from ecological issues to human security. The encyclopedia is co-ordinated and developed by the UNESCO–EOLSS Joint Committee, and sponsored by Eolss Publishers of Oxford, UK. With contributions from more than 7000 scholars, this Internet-based archive is regularly updated and made available free of charge to registered universities and higher institutions in least developed countries. Likewise, disadvantaged individuals worldwide registered through charitable organizations are entitled to free access for one year. Universities from developing countries receive an appropriate discount. EOLSS targets natural and social scientists, engineers, economists, educators, university students and professors, conservationists, entrepreneurs and policy-makers. The Encyclopedia will mature to its full size of about 70 million words (equivalent to about 200 volumes) through regular editions and updates. As of September 2003, EOLSS contained 48 million words, equivalent to about 120,000 pages. (www.eolss.net)
- **The Science Development Network** provides a free-access source of on-line news and analysis about the role of S&T in addressing the needs of developing countries. It is supported by *Nature* and *Science* journals and by TWAS, among others. The Network also offers workshops and training sessions for journalists and public information officers, designed to build capacity in S&T communication and create opportunities to share best practices. In 2003, it added a section on open access and scientific publishing, with resources on access to scientific information in the developing world. (www.scidev.net)

• *In education, training and capacity-building*

ICTs have made a tremendous impact on education and training in many industrial countries, which in turn has led to the growth of the information society. This same success can be replicated elsewhere by using appropriate ICTs to create infrastructure tailored to the needs of particular countries and regions. Without education and training to access and utilize scientific and technical data and information efficiently and effectively, there will not be any significant and sustainable development even if these are freely available.

Below are some interesting examples of models for education, training and research.

- **Wireless networking using Linux in Africa.** The ICTP in Italy launched a project with the Obafemi Awolowo University (OAU) of Ile-Ife in Nigeria in 1995 to overcome the problem of low connectivity in Africa owing to installation costs, insufficient basic infrastructure, the low quality of available telecommunication services and limited financial support. The Programme of Training and System Development on Networking and Radio Communications uses Linux and standard radio-communication technologies in conjunction with Linux software applications to create small area computer networks on campus and a connection to the Internet. The ICTP has trained staff from the OAU and other Nigerian universities to use the hardware and software both at the OAU and at the ICTP in Trieste. (www.ictp.trieste.it/)
- **The Avicenna Virtual Campus** was launched in 2002 by UNESCO in collaboration with the European Commission within the latter's EUMEDIS programme. The aim of the three-year Avicenna project is to accelerate the adoption and use of ICT-assisted open distance learning in 15 universities around the Mediterranean basin by fostering the production and sharing of course content in a multilingual context (http:avicenna.unesco.org/)
- **E-learning for the blind** in the developing countries is a UNESCO project which strives to accelerate the adoption and use of e-learning technologies adapted to the blind: text, Braille, voice and graphic technologies. Since 1996, projects using Braille technologies have been implemented by UNESCO in Egypt, Morocco, India, Qatar and

Saudi Arabia. Others are in the pipeline. The project is building a world network of technological poles involving specialized institutions for the Blind in developing countries, special education providers and international organizations which will individually and collectively provide training and pedagogical innovation, and adapt course content using the new technologies. Special hardware and software tools for the Blind will ultimately exist in English, French, Arabic, Spanish, Hindi and Urdu.

- **Uran-Ukranian Research and Academic Network**
  It is a web portal with information about distance education, information technologies in education and in science, connected with virtual laboratories, on-line libraries and the educational information system "Osvita". Students may access information about economics and management, ecology, medicine, biology, research in the field of physics and mathematical modelling of complex processes, telemedicine, among other fields.
- **Through the Black Storks project**, school children in Europe and Africa are using real-time data in their classrooms to follow migration patterns of black storks between their respective continents. An international programme launched in 1998 brings scientists, naturalists, and schools' teachers and students together in a joint effort to study the habits and behaviours of these protected birds. The storks are tagged with radio markers and their signals are picked by the ARGOS satellite-based data location and collection system – a system dedicated to monitoring and protecting the environment. Children can use the recorded data, accessed via Internet, to calculate flight speeds and compare performances of individual birds. This information is also integrated into a wider ranging study of the environmental factors influencing the storks' migration patterns. (www.explorado.org/solon-new/)
- **The Massachusetts Institute of Technology's Open Course Ware** initiative has started to make approximately 2000 MIT courses and related teaching material freely available for use by faculties and students around the world. (http:ocw.mit.edu)
- **A project in the Philippines is combining ICT-based data and indigenous knowledge** to create 'community maps' of forests and other areas that are environmentally at risk due to economic development. Scientists from the Environmental Science for Social

Change Centre, based at the Manila Observatory, are working closely with members of the local community to create a detailed map of the area. The project combines indigenous knowledge, which provides information about the current ecosystem, and data from satellite-based geographic information systems (GIS), to ensure that the map is spatially accurate. The resulting community map shows how land is currently being used and models various plans for the future. These maps help the community and government resource management professionals develop a sustainable approach for future land use –one that respects both local needs and cultural values.

- **A Virtual Environment and Sustainable Systems Engineering Library Network** is being put together by the World Federation of Engineering Organisations and UNESCO to provide S&T information to developing countries at the high school, technical college and university levels.
- **The Knowledge Management Division of the South Africa Medical Research Council** is developing a Research Translation Unit to guide the use of various modalities of transfer of scientific knowledge to the general public and to evaluate the impact of health research.
- **The Colombian Science and Technology Press Agency (NOTICyT)** is a free service led by the Colombian Association of Science Journalism (ACPC) that informs about science and technology in the country. The weekly bulletin, comprising three to five news articles, reaches Colombian and Ibero-American media via the Internet. NOTICyT is a journalism programme sponsored by the Colombian Institute for the Development of Science and Technology, Colciencias, and the Academy of Medicine. It was created to respond to the lack of public information about the activities of the S&T community. Previous studies showed that Colombian citizens felt S&T were not part of national activities, mainly because the information published in the media was related generally to discoveries made by scientists in the developed world. Colombian newspapers have started to cover their science pages with the news articles produced by Noticyt. Some regional Web sites, such as www.universia.com, have also started to reproduce the information. (acolpc@hotmail.com)

- **The Global Development Learning Network** (GDLN) and The World Bank initiative is a worldwide partnership of distance learning centers (GDLN Centers) and other public, private and non-governmental organizations committed to development learning and development dialogue for lasting poverty reduction. Offering a unique combination of distance learning technologies and methods, GDLN facilitates timely and cost-effective knowledge sharing, consultation, coordination, and training. The World Bank and the Pan-American Health Organization inaugurated the 'Health Partnership for Knowledge Sharing and Learning through workshops and broadcasts to reach those working at the grassroots level. The Health Partnership for Knowledge Sharing and Learning in the Americas will offer programmes and activities to all in the health sector, including practitioners, policy decision-makers at local and national levels, elected officials and hospital personnel. Programme content is designed to help health policy-makers, practitioners and decision-makers conduct discussions on policy and national strategies, develop implementation plans and apply and implement programmes on a full range of health-related issues. (http://www.gdln.org)
- **Digital Nations** aims to address major social challenges (improving education, enhancing health care, supporting community development) through the innovative design and use of new technologies. The consortium's ultimate goal is to empower people in all walks of life to invent new opportunities for themselves and their societies. The consortium focuses especially on populations with the greatest needs — children and seniors, underserved communities and developing nations. (Digital Nations Colombia is one of the national initiatives: www.latined.com/digitalnation/). Digital Nations is an initiative of the MIT Media Lab. (http://dn.media.mit.edu/)
- **The Database for African Theses and Dissertation (DATAD)** will be launched in January 2004 by the Association of African Universities to make dissertations and theses by researchers and students across the continent available on-line. The move is a bid to increase the worldwide profile and accessibility of research by African scholars. The database will act as a quality-control tool for research conducted in Africa, as other researchers will monitor its contents. It will also allow gaps in research to be identified and prevent duplication. DATAD will initially include electronic

versions of research carried out since 1990. A second phase will see the addition of research from 1980 to 1990 and, in the third phase, research conducted prior to 1980.

- **The UNESCO Virtual Laboratory CD-ROM Toolkit** was developed by UNESCO with the help of the ICTP. The Toolkit provides information and free software tools relevant to the creation of a virtual laboratory. It has been designed in such a way as to facilitate the participation of scientists from developing countries in basic virtual laboratories. (www.unesco.org/webworld/portal_freesoft/software/virtual_laboratory)

- *Government initiatives*

Below are some examples of recent government initiatives to promote open access:

Peru sets up science journalism network

The Peruvian National Council of Science and Technology (CONCYTEC) has set up a network to help the country's journalists and scientists share information on S&T. The network — made up of 200 journalists, scientists and public information officers — aims to boost science communication by improving relationships between people working in universities, research institutes, companies and the mass media. A key objective is to support the training of science journalists, both via the Internet and by bringing people together for workshops and other events. It also aims to make science journalism a part of undergraduate courses in communication studies. The creation of the network follows an agreement signed in July 2003 by Peruvian President Alejandro Toledo and political party leaders, social organizations and religious groups to use the mass media to promote creativity, the experimental method and logical reasoning in the general public — the young in particular. www.concytec.gob.pe/redperiodistaspe/index.php

Open access wins German support

Germany's main scientific organizations have issued a joint statement backing initiatives providing free scientific information over the Internet. After a threeday meeting in Berlin, organizations including the Max Planck Society (MPS) and Germany's main research-funding agency, the DFG, were due to issue a call for open access on 22 October 2003. Scientists' working conditions are being modified by the MPS, requiring them to return their copyrighted work to society. Researchers will still be able to publish in scientific journals but, after a period of grace – the length of which is still under discussion – their papers must be deposited in at least one on-line repository. The declaration evolved from a European Union-funded digital project, European Cultural Heritage Online (ECHO), which facilitates access to cultural materials. www.nature.com/cgitaf/Dynapage.taf?file=/nature/journal/v425/n6960/full/425752b_fs.html

Colombia: *Agenda de Conectividad*

Colombia set up the National Council of Informatics in 1997, on which representatives of government and the private sector have a seat. The document *Fundamentals for a National Policy in Informatics* published the same year was inspired by their discussions. Since then, Colombia has institutionalized plans to increase the number of computers and Internet access (there were 2.70 Internet users per 100 population in Colombia in 2001). *The Agenda de Conectividad: el salto a Internet*, is a state policy and a programme designed to provide mass access to ICTs throughout the country. Developing infrastructure and capacity-building programmes are a priority. Under *Agenda de Conectividad: c@mino a la sociedad del conocimiento* (Connectivity Agenda: on the way to the knowledge society), a national network is being put in place to allow an effective exchange of academic information between universities and research centres. It includes the *Proyecto Inteligente* (Smart project) created within the strategy for encouraging the ICT industry. In association with educational institutions, it promotes capacity-building in the development of software and related services for the Colombian productive sector. (http://www.agenda.gov.co/)

Pakistan set to launch digital library

Pakistan is launching in January 2004 its first digital library, giving universities and research institutes in the country access to about 5,000 international journals. The digital library will make it possible for all teachers to interact face-to-face with each other, through Web conferences. They will also be able to share resources and even lesson outlines using this technology. Under the plan, which is implemented by the Higher Education Commission (HEC), abstracts of another 30,000 international journals will be made available through this digital library. According to Ata-ur-Rehman, Chairman of the HEC, the on-line availability of these journals will ensure that scientists across the country learn about advancements in world science. He hopes the digital library will help improve Pakistan's academic standing. www.learningchannel.org/article/view/70708/1/1787

The Inter-American Telecommunications Commission (CITEL)

The Inter-American Telecommunications Commission endeavours to make telecommunications a catalyst for the dynamic development of the Americas by working with governments and the private sector. Placed under the auspices of the Organisation of American States (OAS), it is headquartered in Washington DC, USA. It has 35 Member States and over 200 Associate Members. It has been entrusted by the Heads of State at the Summits of the Americas with specific mandates to intensify its activities in key areas. CITEL has technical autonomy to perform its duties within the boundaries set forth by the OAS Charter, its By-laws and the mandate of the General Assembly. Its objectives include facilitating and promoting the ongoing development of telecommunications in the Hemisphere. www.citel.oas.org

Conclusion

The preparations for the World Summit on the Information Society have undoubtedly enhanced awareness among governments of the important role science and engineering play in building the information society and in contributing to the development of a knowledge society.

For their part, the scientific and engineering communities are also more aware today of the need to reach out to other groups in civil society, in order to ensure that the appropriate legal and institutional frameworks are put in place to ensure the free flow of information. The unimpeded flow of information is, indeed, one of the prerequisites for the development of science, for strengthening the endogenous capacities of all countries to access data and for creating the technological tools necessary to transform data into information for decision-makers.

The preparations for the Summit have also led to the organization of a number of ministerial meetings. These have informed decision-makers at the highest level of the importance of science for providing not only the technological developments that are the lynchpin of the modern communication society but also a solid basis for political decision-making and planning for sound socio-economic development.

Thanks to the mobilization of the scientific, engineering and political communities, and to the outreach activities to the general public, the role of science should be well reflected in the Summit's *Plan of Action*.

For the future, we shall have to be vigilant to ensure that the momentum does not subside once the Geneva Summit is over. The implementation of the decisions agreed upon in Geneva will need to monitored to ensure that the *Plan of Action* is effectively translated into action by the time the Tunis Summit comes round in 2005. This means taking concrete steps to reduce effectively both the digital and knowledge divides separating North and South.

One important mechanism for achieving this will be the development of new partnerships between the private and public sectors, and within North–South cooperative networks. It is these which will ensure that the World Summit on the Information Society contributes to a more equitable society worldwide.