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Organización
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para la Educación,
la Ciencia y la Cultura

Организация
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منظمة الأمم المتحدة
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INTRODUCTION

Assistance to UNESCO Member States in the formulation of national information policy was the main focus of the Information for All Programme's activities in 2008-2009. On the basis of this the following was achieved:

- The establishment of an online IFAP Information Society Observatory (http://ifap-is-observatory.ittk.hu/), continuously updated with new, relevant strategic documents, events, books and experience, annotations and links, following the developments in the area. The Observatory makes up-to-date information accessible, which is, in the first instance, grouped around the IFAP priority areas: Information for development; Information accessibility; Information literacy; Information ethics and Information preservation.
- The publication of six Information Society Observatory Newsletters, which update users on new entries and additions to the Observatory;
- The publication of the present Information Society Policies. Annual World Report.

This Report begins, perhaps untypically, with a list of the major 2010 international and national policy and analytical documents in the Information Society field, so that they can serve as a direct source of reference instead of just as reading summaries. This is followed by a review of the salient Information/Knowledge Society policy issues, as they emerged in 2010.
The Report was written by researchers of the Information Society Research Institute of Budapest University of Technology and Economics. The contents of this publication do not reflect the views or policies of UNESCO. The authors are: Árpád Rab (project leader, trends), Mihály Csótó (statistics, World Map, social network), Szilvia Botos (NRI index), Barbara Sólyom (online services), László Z. Karvalics (science), Szilárd Goda (open government).

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Table of Contents

Science at the crossroads[125]

"*Almost everything that distinguishes the modern world from earlier centuries is attributable to the progress in science*".

Bertrand Russel

Despite its spectacular and thrilling new results attracting popular interest, Science has hardly featured as an independent discipline in the comprehensive information society discourse of recent decades. It only received distinguished attention in the context of economic competitiveness (i.e. how many percent each country spends of its GDP on research and researchers) or discussed in publications and political platforms exploring the reasons for the decreasing popularity of the natural sciences.

Nevertheless, science, which can generate new information and knowledge, is a more specific/characteristic subsystem of the global information society than the informatics and telecommunications industry and the technologies supporting it (referred to as *the world of ICT* in the press and professional circles), or education, that reproduces already existing knowledge.

Already in the 1950s science was an important driver in the emergence of the information society, through "bearing" and giving birth to the leading technologies (computer science, semi-conductors, laser, optical fiber, medical imaging, genetics, space research, etc.). Since then the information society has been increasingly "conditioned to exploration and knowledge" and thus embraced various aspects of science, ranging from the invention of new procedures that revolutionised the mass production of goods through the development of highly sophisticated technologies facilitating everyday life and activities all the way to the innovation of social institutions. In the meantime, it continues to explore and seeks to understand the mysteries of the human body, medicine, the structure and transformation of matter, the processes happening within social groups of different sizes and the complex ecosystem as well as the cosmos. Several new areas of science came into being and developed in the environment of the information society: cybernetics, general systems sciwnce, information theory, communication science, cognitive science, artificial intelligence research, modern management science and future research.

But has there really been a paradigm change? Hav the structural, control and operational mechanisms of modern science (to use James Beniger's term: control structures) been replaced by the qualitatively different forms characteristic of the information society? Does cyberscience or eScience indicate this change, or perhaps megascience? What does the new kind of science (NKS) or the next generation science (NGS) entail and where does it stand? How does service-oriented science differ from science before it?

The sociology of science and press terminology explore the most recent characteristics of scientific development through the analysis of these concepts and metaphors, providing an excellent means to answer the above questions.

[125] The chapter was written by László Z. Karvalics.

Early approaches used the term eScience, or cyberscience[126] in an attempt to describe the new environment of research work, i.e. an environment defined by information and collaboration built on innovative technology.[127] They equally focussed on increased data production, storage, forwarding and interchange capacities, research-oriented networks and resource-concentrating architectures, the newest generation of desktop solutions supporting analytical competence, new forms of interaction and new ways of accessing scientific literature. In fact, scientific work today is virtually exclusively organised around cyberinfrastructure and the extended cyberenvironment of science (or - to use a term coined by Peter Fox and James Hendler - next-generation, digitally enhanced science). This new "platform" enhances operations and capacities in an unprecedented way, thus increasing "output" performance as well as the success and efficiency of research projects. This is how we get from elementary data to high level brainwork with a heuristic element, highly embedded in social space. This structure is illustrated in Table 9.

Table 10: The taxonomy of eScience

Levels and suggested names	Operation supported	Central element	Equivalent
1st level Data input	Collection Production	Data	Quantity (Elementary unit, byte)
2nd level Computing capacity	Processing	Calculation	Processing time
3rd level Pre-processing	Ordering, integration Analysis	Interaction	Adding value Usability
4th level Creative brainwork	Transformation	Community	Novelty value

Technology easily crosses over the boundaries between categories (the so-called grids, for example, practically cater to all then four levels of operation) and strong "noding" can be seen between the individual levels too. Levels 2 and 3 are brought into each other's proximity by science centers, and the process towards integration clearly will not stop at the boundaries of level 1 and level 4. Levels 3 and 4 are also so strongly "drawn" to each other that, emphasising their common quality, Paul A. David proposed the term collaborative eScience already in 2004. Levels 1 and 2 "shifts into" the collective category of peta-scale scientific data management because of the analogue nature of the challenges they face and the large number of hardware and software elements they have in common. Distances have been reduced: now it is not at all surprising when a scientist at level 4 needs level 1 sensor data, which he can receive within a really short span of time thanks to the capacity of interconnected systems. It is therefore justified that an increasing number of theoretitians propose the hypothesis of megascience as the next stage of development in eScience through the fusion of all the levels into one megasystem.

[126] Another approach includes the sub-disciplines of science studying the distinctly separable phenomena of cyberspace, ranging from Internet psychology and cyberculture studies to the science of networks to Internet research. It must be noted here that around the turn of the millenia a distinct discipline emerged for the research of the information society, called information society studies.
[127] For the most comprehensive review see Christine L. Borgmann: Scholarship in the Digital Age. Information, Infrastructure, and the Internet (MIT Press, 2007)

Table 11: The road to the full fusion of cyber infrastructure levels

<table>
<tr><th>Levels</th><th>“Expansion” push from the middle</th><th>Existing integration entities</th><th>Future fusion</th></tr>
<tr><td>1st level
Data input</td><td></td><td rowspan="2">Peta-scale scientific data managemenet</td><td rowspan="4">SEAMLESS SUPERNETWORK (with hybrid clusters)</td></tr>
<tr><td>2nd level
Computing capacity</td><td rowspan="2">↑
Science centers
↓</td></tr>
<tr><td>3rd level
Pre-processing</td><td rowspan="2">Collaborative eScience</td></tr>
<tr><td>4th level
Creative brainwork</td><td></td></tr>
</table>

At its birth[128] „*megascience*” referred to the fact that experimental sciences had entered an era where new discoveries can be made by small scientific communities but already require big money and big machines, thus planning, implementation and research can only be realised through cooperation and collaboration, with considerable international cooperation and in scientific centres. The best known, currently operative examples for megascience include the *Large Hadron Collider* (LHC) project of CERN in Geneva, the *Hubble Space Telescope* and the *Relativistic Heavy Ion Collider* (RHIC) in Brookhaven, USA; the *Facility for Antiproton and Ion Research* (FAIR) is being constructed in Darmstadt, a new tokamak, called the *International Thermonuclear Experiment Reactor* (ITER), is being built in Cadarache, France, while the *Extreme Light Infrastructure* (ELI), simply reffered to as the superlaser centre, with Szeged as its centre, is in planning stage. There will be more and more tools used by megascience, and we can already look ahead to 2016 (Chile, Large Synoptic Survey Telescope) or even to 2021, when the *International X-ray Observatory* (IXO, the largest space telescope ever built for the analysis of shortwave radiation) is planned to be opened in the cooperation of NASA, ESA (European Space Agency) and JAXA (Japanese Space Agency).

Quite naturally, the big machines used by megascience are burdened by an extremely heavy data load. The LHC in Geneva, run to maximum capacity, generates 15 million gigabyte data annually, while the space telescope in Chile receives 30 thousand gigabyte daily (!). Jim Gray, who passed away in 2007, named data intensive sciencewith a capacity to deal with such volumes, “the fourth paradigm” of scientific research.

The data-intensity of the sciences is not only increased by the big machines of megascience but also the digitalisation of all the texts of human culture as well as the millions of measurement sensors. For example, the *ARGO* project, mapping the physical condition of oceans, provides a convincing illustration for the changed scale of signals and its consequent effects. More than forty countries participate in the operation of the joint, satellite-aided marine measurement network, which at the end of 2007 already consisted of some 3,000 profiling floats, which are rising and sinking devices travelling on currents and transmitting signals for many years to measure the temperature and salinity of the ocean. Between 1999 and 2004 alone, in the first five years of its operation, there were 1700 floats which

[128] OECD has been running its *Megascience Forum* since 1993, which in its activities and publications mainly concentrates on the significant international projects in oceanography, particlephysics, astronomy and genetics.

"transmitted one thousand times as much information than all the measurements provided in the previous centuries"[129]. ARGO is also a great example for the new scale of data environment producing new scientific results: researchers at CalTech analysed more than one million temperature profiles transmitted by the floats and established that the surplus heat absorbed by the Earth is mainly "stored" in the deep layers of the southern oceans; since then our planet's heat balance can be modelled more accurately.

Miniature sensors used mainly to observe the natural and the built environment and large sensor networks capable of cooperation and soon to have features of "behaviour" primarily make up for the deficiencies of human sensory abilities. The "revolution of sensors" has long begun in the depth of oceans, volcanoes and in the higher layers of the atmosphere, thanks to which we know much more than ever before about subsurface currents and processes under the earth's crust or in vessels storing hazardous chemicals. The human body was added to the "sensor map" only in the past few years and opened up the new horison of nanodiagnostics: microgadgets dispatcehd or (built into) the key points of the human body can play a revolutionary role in medicine in the same way as the x-ray, ultrasound or tomography did in the area of medical imaging.

Thus, on the abstract flowchart of eScience a few megamachines and millions of sensors feed the incoming signal flow, the signal transmission and the most high-tech informatics solutions carry out the processing, while the members of research community working together to interpret these signals and exchange meanings are effectively linked together by solutions systems of network culture adapted to science[130]. In the past one or two years groups of scientists developed their own Facebook-type interfaces and dedicated social networks[131] at such a fast pace that some analysts claim that there are already "too many of them". A large number of related science blogs have also been launched (they are collected at scienceblogs.com), microblogging is Twitter's instant messaging adapted to science topics, the online activities of researchers are aggregated by Friendfeed, where participants can engage in real-time discussions or scientific dialogues in private chatrooms, enjoying the benefits of lifestreaming. CiteULike and Connotea help researchers to manage social bibliography, Del.icio.us and Magnolia support social bookmarking displayed in the form of comments. Scientific presentations can be shared online with the help of Slideshare, while specialised video sharing (SciVee, JQve) and screencasts/podcasts (Bioscreencast, NPR) are also available.

Paul A. David's thesis – according to which the starting point for the evaluation of the new digital tools must be that they profoundly alter the ways in which "ordinary" scientific programmes are organised, supported and run – has been used as a point of reference for a long time but soon will need to be amended. The team of authors of the document *Towards 2020 Science*, released at the beginning of 2006, go as fas as stating that merging together

[129] The volume of data is even more astounding in the case of the Sloan Digital Sky Survey project in New Mexico: *in the first two days of its operation the telescope collected more data than what had been compiled during the entire history of astronomy*. The final version of the resulting "stellar catalogue" contains 140 terabyte of information about 230 million space objects.
[130] Részletes áttekintésüket (még 2008-ból) ld. Neil Saunders: Science networking online http://scilib.typepad.com/science_library_pad/2008/12/science-networking-online.html
[131] Csak néhány ismertebb példa: BioMed Experts, Epernicus, LaboraTree, LabMeeting, Nature Network, Sciencestage, Sermo, TiroMed

with individual disciplines information technology has exceeded the infrastructure revolution: it results in the profound transformation of science itself. Computers, networks and digital equipment with software and applications no longer contribute to future science at metalevel and in a service-oriented way but rather at object level. Information technology not only helps in solving problems but its terminology, methodology and principles are organically built into the tissue of studying a given field of science, thus creating new “qualities”. Biochemistry, genetics, brain research and space research are now unimaginable without the informatics apparatus that evolved over the past decade.

Simultaneously with the above change the interpretation of megascience has also expanded since it is not only special and highly expensive equipment that is necessary in the basic sciences but also a concentration of researchers: team work is no longer sufficient to produce new scientific results since many fields of science require the coordinated and well-organised concerted efforts of increasingly large scientific communities. The Human Genome Project at the end of the last millennium already demonstrated what hundreds of researchers working together are capable of: thanks to their collaboration the human genome map was made a decade earlier, according to estimates. To borrow Lewis Mumford’s idea: in addition to big machines, the knowledge of a host of linked-up scientists can also be regarded as the megamachines of science.

It is important to notice that the intensification resulting from connecting researchers who previously studied the same fields independently does not increase the number of people participating in the problem-solving processes but rather makes their cooperation more efficient. Since scientist collaborating in this new way share not only their time with each other but also the content of their servers, what happens is that their previously local problems shift to a a more comprehensive level. Moreover, since the logic of cooperation, put an end to the pressure of withholding data, which was a typical phenomenon in the past, since now every participant is motivated to share knowledge, the former time deficit of processing was replaced by increased time efficiency (A good example for this is the *Mars Reconnaisance Orbiter* (MRO) which attained Martian orbit in March 2006. The abilities and capacity of MRO exceeded those of its “rival” space equipment to such an extent that it generated a sudden and extensive public release of thus far withheld results.)

By now there are more and more signs and negative consequences of the fact that the results achieved in the areas of automation, extended capacity signal production and signal processing are not matched by an increase of those employed in research work. The formerly exponential trend of increase, i.e. a continuous growth in the number of scientists starting from the early 1700s (hence the saying by Derek de Solla Price, according to which the percentage of scientists that ever lived is 90% at any given present time) dissipated already at the end of the 1970s. With previous trends taking a reverse directiion, the pace of natural population growth now exceeds that of those employed in science, so despite the absolute number of scientists showing an increase, their proportion within the total population is decreasing. In 1977 this proportion almost crossed the 1,000 per 1 million inhabitants threshold level (still only representing some one thousandth!) but it has been decreasing ever since: around the turn of the millennium it was only at 876. And even though the indicators are the worst in Africa and in the Arab countries, a downward trend can be percieved in India, while stagnation can be seen in China and even in some of the most developed countries. However, countries at the vanguard of science are not primarily concerned about the lack of extensive growth but are rather facing intensifying difficulties concerning the "charging up" and reproduction of the institutional research system, since whereas the unprocessed volume of data might be "unrealised intellectual profit", the lack of sufficient research staff holds the threat of tangible future damage.

The shortage of staff is not simply one of the new phenomena in the world of science but perhaps the most crucial sign of a crisis developing in regard to the system-based operation of science, something that has not been attacked head-on either by international organisations or national science policy makers. Up until now the continuously increasing number of those employed in science went in tandem with the process of differentiation that took place in the various fields of science: the number of researchers employed in individual branches (represented by research institutes and university departments) remained more or less the same, and the registered increase in numbers was mainly produced by the emerging new interscientific hybrids, inter- and multidisciplininary areas, new scientific orientations as well as new trends and schools that developed within the scientific disciplines. This dynamic is sustained by the development of science (some twenty thousand (!) different scientific occupations are registered by the Bureau of Labor Statistics in the USA[132]); however, the noticeable slowdown in the number of researchers has led to a relatively decreasing number of researchers working in particular scientific domains. Thus, the shortage of brains that could be involved in the processing of the increased volume of signal generation is more and more difficult to converte into meaningful production. All this produces crisis symptoms not on account of the "statistical nature" of the figures but because of the increasingly insufficient feedback cycles of knowledge production caused by the shortage of researchers: being aware of the nature of the unsolved scientific problems (and the civilisational challenges behind them) everyone concerned has clearly come to realise that in most cases even if the present number of all the researchers across the world – which according to some rough estimates is around 60 million – were multiplied, it could not provide the problem-solving capacity required.

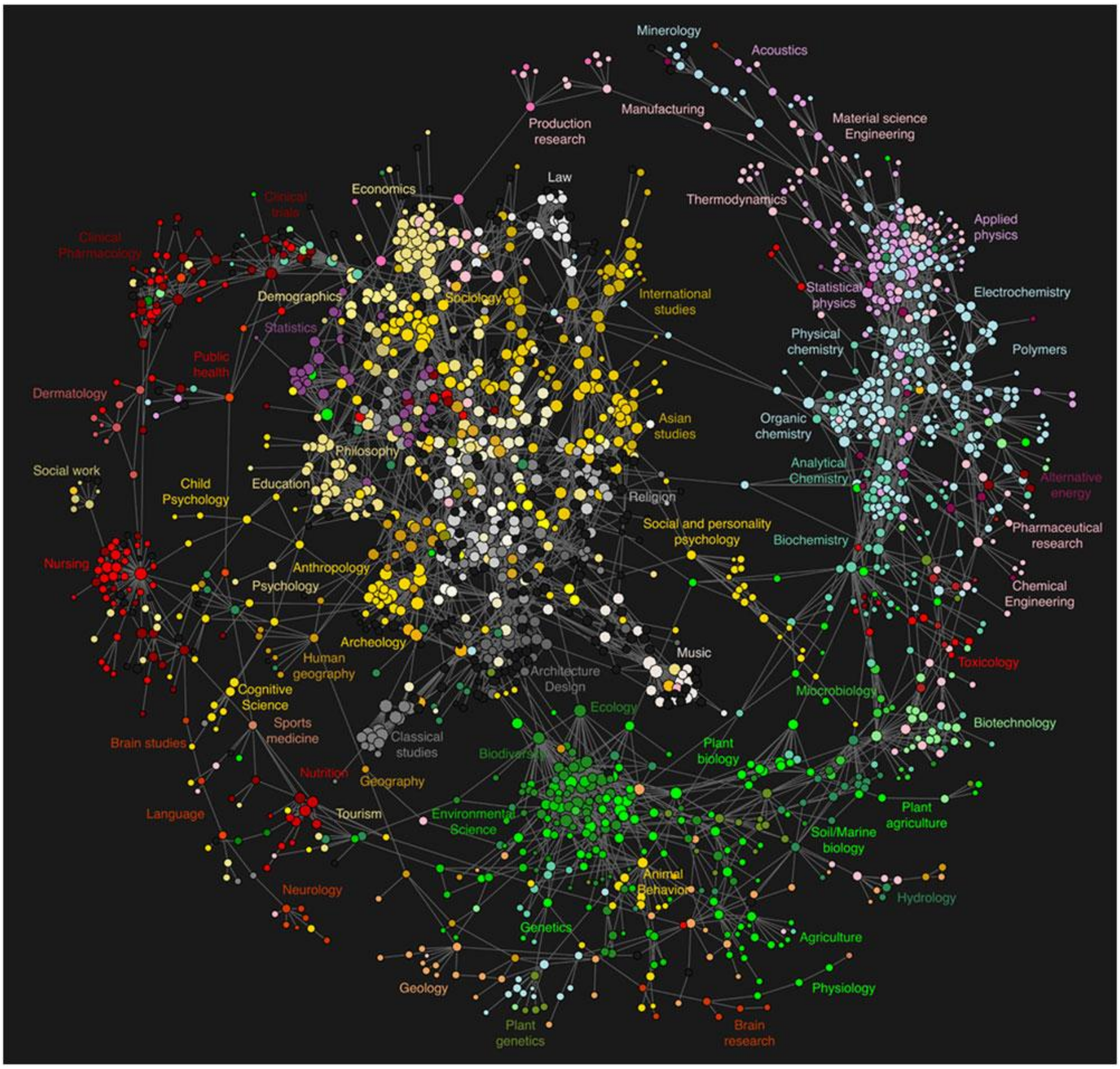
Since there is little hope at the moment of changing the interest, control and financing structures that developed in the industrial era, the international scientific community has moved in two directions. On the one hand, it started to include players outside the sciences in ongoing scientific projects (this trend has reached staggering proportions since the turn of the millennium), and on the other hand researchers working in various fields of science have started to increasingly "turn toward each other" and form new problem communities without establishing new disciplines, so-called scientific clusters, which welds together individual areas of research and bringing researchers closer together in an unprecedented

[132] http://stats.bls.gov/soc/soc_e0a0.htm

way, also creates new synergies, knowledge hubs and knowledge junctions between the natural and social sciences as well as the humanities[133].

Johan Bollen and his co-authors drew up the interconnective map of science by analysing the search-and-click patterns used by researchers.

Figure 20: The interactive map of science[134]



There are several examples of involving human resources in scientific work from outside science. “Professional” scientists in the sciences that heavily rely on observation (primarily astronomy and ornithology) have long been intent on working together with amateurs or hobby researchers, to whom they owe a lot of important results and whose eye- and brainwork has proven to be a constantly available resource. A significant step in the emancipation of these amateurs was the coining of the name ProAms (*professional amateurs*) in 2004, which legitimised the category of experts producing an equal level of performance

[133] See the EU’s Mapping Foresight. Revealing how Europe and other world regions navigate into the future by Rafael Popper, dated November 2009. ftp://ftp.cordis.europa.eu/pub/fp7/ssh/docs/efmn-mapping-foresight.pdf
[134] Clickstream Data Yields High-Resolution Maps of Science. PLoS ONE March 2009 Vol. 4. Issue 3. The figure can be downloaded from: http://www.lanl.gov/news/albums/science/PLOSMapOfScience.jpg

to that of professionals. Spectacular and successful projects were launched utilising online crowdsourcing, which had already proven effective in other areas, i.e. they outsourced tasks through an open call to complete data-intensive research projects, at times mobilising volunteers in the hundreds of thousands (for "best practices" see projects like Galaxy Zoo, Stardust, Systemic).

Thus, in some areas citizen science has now come relatively close to fulfilling the normative promises of open science. Paul A. David, who is perhaps the most passionate analyst of open science, has written dozens of works presenting how science, which is "open by nature", "closed up" over the course of human history, reaching back all the way to the Renaissance, and then, after centuries of isolation, stepped upon the path of "democratisation" with eScience and the former aristocratic distance between the disciplines was replaced by coming together. Others assert that the quiet revolution of science has already taken place: science has never been as "open" as now and the most important frontline areas of the "reconquering mission" can be clearly seen: environment, health, social networking services – areas where scientific performance is the most meaningful for "ordinary people". The borderlines between scientific activity as "employment" and "work" are becoming blurred; Bruno Labour illustrated this trend by distinguishing science from research.

The previously outlined demand for brainwork cannot be satisfied by ad hoc, perchance, changeable and unreliable crowdsourcing. The future of citizen science – and science as a subsystem – can only be guaranteed if a viable educational approach facilitates the study of science to become a competence of all citizens in the form of information or scientific literacy added to the traditional literacies (writing, reading, mathematics). There are some major online success stories of popularising science (such as the overnight success of the Khan Academy[135]) and a small number of less outstanding yet exciting experimental initiatives called learning by research, aimed at actively involving 12-18-year-olds (and, just as importantly, their teachers) in scientific problem-solving projects. On the one hand, in these projects education helps science to add value but they also represent a renewed approach to science with new motivations driven by commitment, the freedom of choice and the feeling of contributing to the solution of shared problems. Looking at the issue from this perspective, the futility and stereotypicality of the discourses about the decreasing popularity of science among young generations jumps into focus, as does the hopelessness of the majority of attempts aimed at finding the solution to the problem. The loss of ground by the (natural) sciences is not to be sought in the selective pedagogical deficit that can be counterbalanced by increasing the efficiency of teaching or by reforming the methods of popular science. Similarly to science, the present educational system is unable to break out of the confines determined by its industrial roots and is thus rendered unfit to keep pace with the changes resulting from the comprehensive cultural transformation that occurred in the values, interests and activities of young generations. The school and science of the information society should not mean "forcing" masses of outdated knowledge into children's

[135] Salman Khan, a Bangladeshi American graduate of MIT, distributed the tutorials he initially made for his family on YouTube and his videos with a personal tone became so popular that since 2009 – thanks to his supporters – he has been working full time on creating the world's first world-class virtual school.

heads from the outside but instead the collaborative study of science based on commitment and inner choices and responding to civilisational and local challenges.

Interestingly, the "epistemoilogical turn", which is increasingly manifested in virtually all areas of science, points in the same direction. One of the most exciting developments of recent years in a number of disciplines not closely associated with one another is the growing presence of narrative structures, or presentation through storytelling. The event and the metaknowledge related to them have become a kind of common linguistic and rhetoric code in many areas of science, from biochemistry to anthropology. The 21st century brought along a new language of science[136] in which metaphors and metonyms, and verbal-symbolic thinking will play a more important role in understanding, building conceptual bridges to enable communication between the various micro- meso-, and macro-level layers of reality and the various fields of science, in the development of creativity and motivation (for example attaching greater importance to humour and aphoristic style as concise representations of complex content.) The same thing drives the renaissance of visual understanding. The need for a new power of visualisation and representation, scientific infographics (and the emergent science and art of infoarchitecture) have not only been shaped by the pressure exerted upon them by data-intensive sciences but also by the need for the "condensed" representation of scientific results and the desire to minimalise the time researchers need to understand new content. Thus, the new generation tools of representation by nature have efficacy, cognitionary and democratising implications.

All things considered, it can be seen that science in the information society, which for a long time had been trapped in the structures that developed in the industrial era, managed to go through a significant transformation to finally arrive at today's 2.0 state, and it has taken the first step towards reaching its true potential in the qualitatively new 3.0 structures. Since these changes are happening in front of our very eyes, we can follow the development of one of the most exciting trends in the information society in the coming period. Taking Ian Foster's taxonomy[137] a bit further the key elements of science 3.0 are summed up in the table bellow.

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[136] Gregory S. Yablonsky wrote a book devoted solely to this theme, which was published at the beginning of 2011 (Going Through the Mirror: Science for the 21st Century Metaphors and Metonyms in Science, World Scientific Publishing Company)

[137] Foster, Ian 2007

Table 12: Science 3.0

Science 1.0	Science 2.0.	Science 3.0.
Megabytes, gigabytes	Terabytes, petabytes	Exabytes, brontobytes
Resource places	Services	Universal support environment
Journals	Wikis	Ambient information environment
Institutional tradition	Science policy	Social innovation
Individuals	Communities	Hybrid superclusters
Community codes	Science gateways	Self-organization
Supercomputer centers	Campus and national grids	Mesh-ups
Scripts	Workflow and quality management	Megaworkflow
Computational science	Science as computation	Science as everyday activity
Mostly physical sciences	All sciences and humanities	Bio-and anthropocentric integration
Thousands of computationalist	Millions of scientists	Everybody – (Billions)
Government and industry funded	Government, industry and privately funded	Multistakeholder and self-funded
Laboratories	Labs, Megascience tools, sensors	Scientific „Internet of things"
Taxonomies	Paradigms, Ontologies	Narrative structures, metaphors

The world's leading countries based their responses given to the global economic crisis on the solid contention that the new value created by science is the foundation of economic growth and the employment it generates. The decision-makers are fully committed to the belief that investing into science results in more competitive firms as well as more and better workplaces. The quintessential question in the developments of the next one or two years will not be whether scientific facilities will be able to "struggle back" to the levels of financing and application they enjoyed prior to the crisis but whether their seeking a way out of the crisis is "3.0 enough", in other words, to what extent will it embrace the institutional, infrastructural and human resource management paradigm change in science.