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Networks of Trust:

Will the New Social Media Change Global Science?

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SPECIAL
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The 6th Forum on the Internationalization of Sciences and Humanities

- 3 Preface**
by **Helmut Schwarz**, President of the Alexander von Humboldt Foundation and **Konrad Samwer**, Chair of the International Advisory Board
- 4 Central Points of Discussion**
A Subjective Summary
by **Barbara Sheldon**,
Strategic Planning Division
Alexander von Humboldt Foundation
- 6 Science and Diplomacy**
by **E. William Colglazier**,
Science and Technology Adviser to the
U.S. Secretary of State



16 Impressions

- 18 The Impact of Social Media and Networks on Research**
by **Riley Crane**,
Society in Science
Senior Postdoctoral Fellow
Human Dynamics Group
Massachusetts Institute of
Technology
USA

- 23 Science 2.0 and Research Funding: The Potential for Research Organizations to Pave the Way**
by **Mark A. Suskin**,
Deputy Director
Office of Cyberinfrastructure
National Science Foundation
USA

- 28 A Virtuous Cycle: Building Science Capacity through Academic Networks**
by **Romain Murenzi**,
Executive Director of TWAS,
the academy of sciences for the
developing world, and former
minister of science & technology for
the government of Rwanda



Inside the IAB

- 34 The International Advisory Board**
- 35 Forum on the Internationalization of Sciences and Humanities**



36 Imprint

Preface

Dear reader,

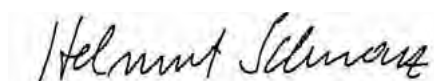
At the beginning of the 21st century, academic networking seems more important than ever. Many of the ‘grand challenges’ that the global community faces today have scientific dimensions. Finding effective, sustainable solutions to these challenges requires international research collaboration. Such collaboration, which has often been at the forefront of technological, economic, and, at times, societal change, is currently undergoing profound changes in its own right. The Internet and, in particular, social media are driving forces of globalization and do not stop short of academia. As ever more virtual networks span the globe, the rapid advances in communication technology not only change the ways new knowledge is disseminated. They may, in fact, alter how scientists collaborate in the future and thus influence the very nature of how science is done.

In order to examine some of the opportunities and challenges that these developments entail, the International Advisory Board of the Alexander von Humboldt Foundation convened the 6th Forum on the Internationalization of Sciences and Humanities in October 2012 to discuss the question “Networks of Trust: Will the New Social Media Change Global Science?” A broad and diverse range of high-profile perspectives was presented. On the eve of the Forum, Dr. E. William Colglazier, Science and Technology Adviser to the U.S. Secretary of State, opened the debate with a keynote address on science diplomacy. Discussions during the Forum were driven by established academics as well as postdocs, representatives of the developed as well as the developing world, and political and administrative stakeholders on national, European, and global levels.

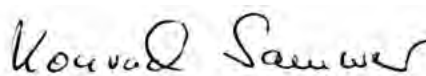
Aiming at a better understanding both of the significance of social networking for global science and, in more general terms, of the future of international research collaboration, central questions discussed at this year’s Forum were: How will the new social media change scholarly communication? What will be the impact of new social networks on international research collaboration and traditional networking? What will be the benefits and the challenges both with regard to the solution of scientific problems as well as the individual researcher’s career development?

Our publication is intended to make aspects of this fruitful exchange available to a wider public within and outside of Germany. We hope that by offering an overview of salient facts, informed thought, and important strategic developments presented at the Forum, we will be able to contribute to fostering further debate on these far-reaching and highly relevant issues.

Sincerely,



Helmut Schwarz



Konrad Samwer



Helmut Schwarz
President
Alexander von Humboldt Foundation



Konrad Samwer
Chair
International Advisory Board



Central Points of Discussion

A Subjective Summary by Barbara Sheldon

Barbara Sheldon
Head of Division Strategic Planning
Alexander von Humboldt Foundation

International scientific collaboration is undergoing profound change at the moment. The Internet and, in particular, the rise of the social media and social networks have contributed hugely to globalization. The Forum looked into the very nature and future of research collaboration and academic networking in the 21st century.



1. **The days of the solitary scientist are gone.** Scientists throughout the world are faced with the emergence of the new social media and the central question of whether they are simply an instrument, the modern version of pencil and paper, an issue of the surface, or whether they constitute a paradigm change that will deeply affect science and will go to its very core. At present it is hard to predict the quantitative and qualitative changes that will follow in the wake of the new social media. While the internet, the instrument of the world of “Web 1.0”, is nowadays positively regarded by scientists, there is no unanimously favorable assessment of “Web 2.0” as yet.
2. **The social media have shaken the traditional concept of expert versus non-expert.** While science and scholarship have usually been seen as a very elitist pursuit, a matter of the few select, the social media have given visibility to science and scientists to a degree unimaginable before. People in remote areas of the world have access to information and knowledge, can even tap into scientific discourses. Specific scientific problems have been put out in the social media and solved through crowd intelligence. Collections of and access to large amounts of data have become possible through social media, leading to the solution of scientific problems.
3. **The new social media may lead to a fundamental epistemological change of science and scholarship itself and thus go to the core of science.** Scientific identities may in the future be molded in the social media. The social media may change the way we collect large amounts of data; they may enable research collaborations, “global academies”, otherwise unimaginable; they may change the way we acquire knowledge, e.g. by granting access to the global academic community; they may replace the old paradigm of “publish or perish” with “get visible or vanish”; they may expose bad science more easily, while at the same time lacking a system of quality control. By the fact of engaging the scientific community in constant communication the social media may suppress originality. While one can theoretically share everything, the community is at the same time too large, meaning that you cannot share too much.
4. **The social media have grown organically.** While the science establishment these days are in many ways still “digital dinosaurs”, preparations need to be made for the day when the Web 2.0-savvy young generation of scientists moves from being mentees to mentors and become the establishment themselves. While the social media are initially a means, not an end in itself, they may lead to the creation of alternate groups with “Deutungshoheit”. How do we react to these claims to legitimacy? The challenge now is to organize the social media in a way that the positive sides can be used and funded, while the core of science needs to be protected: a scientific world that is driven by the search for knowledge and truth. So far it remains to be seen how the young generation will develop the critical judgment necessary to deal with the social media.
5. **The emergence of the social media calls for new concepts on behalf of scientists, science funders, science policy, and science publishers.** At present, strategies and awareness for the topic are still lacking. We also do not know enough about the use of social media in different countries of the world as well as within different disciplines. Research on the social media is necessary as well. Any effort on the side of science administrators and research funding organizations to venture into major social media activities should involve the target user groups in order to create intelligent and suitable concepts and tools.
6. **Scientists should be the gate-keepers of trust.** They should have the capabilities to lead the way into the new social media area and thus react to a challenge society is facing in a larger sense. While many of us may think today that people will continue to like small networks with people they know and trust, it may well be that we are moving towards a future where we will have to re-think our concepts of networking and of trust. ■



E. William Colglazier

Science and Technology Adviser
to the U.S. Secretary of State

Science and Diplomacy

E. William Colglazier, Science and Technology Adviser to the U.S. Secretary of State, shares his views on how to promote scientific and technological innovation around the world, and how science acts as a powerful force for diplomacy and peace.



Introduction

It is a pleasure to speak about “science diplomacy” to the International Advisory Board of the Alexander von Humboldt Foundation this evening. I have been the Science and Technology Adviser to the U.S. Secretary of State since July 2011. Most of my career has been outside of government, first as a theoretical physicist, then as an academic focusing on science and technology policy, and then for twenty years at the U.S. National Academy of Sciences (NAS) and the National Research Council. In the latter role, I helped to oversee studies advising the American government and public on issues where insights from science and technology were needed.

I will give a simple-minded definition of what I mean by science diplomacy. By “science,” I mean not only the physical and biological sciences, but also the social sciences, engineering, and medicine. Science diplomacy is: (1) science and technology aiding diplomacy (even if just by opening doors for dialogue), (2) diplomacy advancing science and technology (such as by negotiating multinational arrangements for building large facilities), and (3) science and technology helping to solve national, regional, and global problems (such as by creating new options and paths for making progress on the “wicked problems” too difficult for politicians to resolve alone). The purpose of science diplomacy is to help improve relations between countries and make all people more secure, healthy, peaceful, and prosperous.

My office at the State Department helps to facilitate science diplomacy, but also helps to build the scientific and technical human capacity inside the Department, assists our bureaus and offices on specific matters where science and technology are relevant, and helps to anticipate scientific and technical issues that may affect international relations and/or disrupt societies in either positive or negative ways. We also work closely with the Office of Science and Technology at the U.S. Agency for International Development (USAID). Through creative programs, this office – which is headed by the Science and Technology Adviser to the Administrator – has greatly expanded the role of science and technology in addressing development challenges of the poorest countries.





Science as a common global language

In talking with representatives of many countries about science and technology over the past year, I have been struck by the fact that nearly every country has put at the very top of its agenda the role of science and technology for supporting innovation and economic development. This observation has been true for countries at every level of development – not only for countries like Germany, Japan, China, India, Brazil, South Korea, and Singapore, but also for countries like Mexico, Colombia, Chile, South Africa, Indonesia, Czech Republic, Malaysia, and Vietnam. They are all seeking advice on the right policies and investments that can help their societies to become more innovative and competitive to ensure a more prosperous future for their citizens.

Why does every country now have a “laser-like” focus on improving its capabilities in science, technology,

and innovation in order to be more competitive in this globalized, interconnected world? My guess is that these countries see two trends clearly: (1) science and technology have a major impact on the economic success of leading companies and countries, and (2) the scientific and technological revolution has been accelerating. If countries do not become more capable in science and technology, they will be left behind. The upside is great if they can capitalize on the transformative potential of new and emerging technologies. As one example, the information and communication technology (ICT) revolution has shown the potential for developing countries to use new technologies to “leapfrog” over the development paths taken by developed countries, such as with mobile phones in Africa.



“Countries also recognize that almost every issue with which they are confronted on the national, regional, and global level has an important scientific and technological component.”

The strategic importance of science and technology

Countries also recognize that almost every issue with which they are confronted on the national, regional, and global level has an important scientific and technological component. This is true whether the issue concerns health, environment, national security, homeland security, energy, communication, food, water, climate change, disaster preparedness, or education. Countries know they have smart, creative, entrepreneurial people. They believe their people can compete, even from a distance, if the right investments are made and the right policies are implemented. And they know that to become more capable in science and technology and to create innovation and knowledge-based societies, they must collaborate with the world leaders in science and technology.

New and emerging technologies have also affected the trajectory of fundamental science and engineering research by creating new capabilities for exploring and understanding the natural world. We are only at the beginning of exploiting the potential of these new capabilities. This is another reason for the

acceleration of the scientific and technological revolution, progressing at such an incredibly rapid pace that it is hard to imagine, much less predict, what new transformative possibilities will emerge within a decade. Scientists are not much better at predicting the future than anyone else. As renowned computer scientist Alan Kay said, “The best way to predict the future is to invent it.”

How have these developments affected science diplomacy? For the U.S. and Germany, science has become a strategic asset for our diplomacy because all countries want to engage with our scientists and engineers, with our universities and research laboratories, and with our high technology companies. They want to see how we innovate and how we connect research and development to the productive sector. This desire is true even for countries where governmental relations are strained or non-existent. So my colleagues and I spend much of our time in dialogue with other countries about how to stimulate innovation from science and technology.





Spurring innovation in the U.S.

The fundamental principles describing what to do to spur innovation are generally well understood, but complicated to implement. These principles are clearly described in a report entitled “Rising Above the Gathering Storm”, published by the U.S. National Academy of Sciences and National Academy of Engineering in 2005.¹ The report was initiated by a bipartisan request of the U.S. Congress asking what the U.S. should do to ensure it would be able to compete in the 21st century and produce good jobs and a high standard of living for our citizens. The expert committee that wrote the report included leaders of industry, presidents of research universities, and Nobel Prize laureates. Many of the recommendations in this report were enacted in legislation through the America Competes Acts of 2007 and 2010.

The report’s recommendations for the U.S. government are grouped into four areas. All four require additional investments and improved policies, which are relevant for any country that wishes to enhance its science, technology, and innovation. The first is to

improve and strengthen the primary and secondary educational system, when children first enter grade school through high school, so that more students are not only well-trained in the sciences, mathematics, and engineering and the scientific way of thinking, but also interested in pursuing careers that depend on these disciplines. The second is to provide more support for undergraduate and graduate students at universities and for students at vocational schools who pursue advanced training in science and engineering. The third is to provide more support for research and development in universities and national laboratories. The fourth is to build stable and supportive government policies that facilitate, rather than retard, building an innovative ecosystem and a culture of innovation in society.

Building human capacity is the key element in creating an innovative society. We have turned off too many young people from science by teaching in boring ways – emphasizing memorization of facts rather than teaching by inquiry – and by having too many



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teachers in the early grades who are not adequately trained in the sciences and mathematics. Also essential are strong research universities and laboratories that carry out fundamental research funded by multiple government agencies. Many U.S. research universities have created interdisciplinary research centers with government and industry support, requiring expertise from a range of scientific and engineering disciplines focusing on fundamental research in areas that are important for future advances and applications, such as in biotechnology, nanotechnology, smart grid, secure computing, synthetic biology, and robotics. These interdisciplinary research centers help to carry on the legacy of institutions like Bell Labs that contributed so greatly to innovation in the 20th century, a story that is well-told in the recent book “The Idea Factory: Bell Labs and the Great Age of American Innovation.”²

The importance of the private sector in research and development and in the innovation system cannot be overestimated. Seventy percent of the research

and development in the U.S. occurs in the private sector, carried out by R&D facilities in our large companies and by entrepreneurs and innovators in small to medium-size companies, building on more basic research funded by government. An innovative ecosystem also requires policies that promote efficient markets, strong intellectual property protection, venture and risk capital investors, angel investors, and foreign direct investment and trade. Further required is the free exchange of information in fundamental research, tax policies that promote innovation and private sector investment, enabling infrastructure investments by government, and bankruptcy policies that permit second chances. Additionally important are policies that encourage university faculty to start small companies to exploit promising ideas; immigration policy that attracts the best and brightest from other countries; and government programs that encourage entrepreneurs, help to accelerate innovation through open competitions and prizes, and support research and development by small entrepreneurial companies.





Non-governmental leaders in science diplomacy

Let me now return to science diplomacy, which depends on a country having an innovative ecosystem. Some of the greatest science diplomacy assets for the U.S. and Germany are our non-governmental scientific institutions and people. I will give some examples familiar to me, beginning with two individuals who were mentors. They were great scientists who also made significant contributions to science diplomacy. Neither ever worked inside the government. One is Paul Doty, Professor of Biochemistry at Harvard, who died in 2011 at the age of 91. He was a world-class biochemist who served on President Kennedy's science advisory committee. He devoted much of his career trying to reduce the risk of nuclear war through engaging with Soviet scientists about nuclear arms control. He created the Center for Science and International Affairs at the Kennedy School of Government at Harvard University and the Program in Science, Technology, and Humanism of the Aspen Institute – two places where I worked with him. He served for many years on the Committee on International Security and Arms Control of the NAS. This committee was the main “back channel” for communication between American and Soviet scientists on arms control during the height of the Cold War. The Soviet scientists involved in these dialogues later became the key scientific advisors to Gorbachev,

and their influence helped achieve the breakthroughs that occurred in arms control between these two countries. Nobel Laureate Jim Watson said of Paul: “His strength was in never wanting power.” He was an academic scientist who made seminal contributions to science diplomacy.

Another individual is Sherwood Rowland, Nobel Laureate in Chemistry and Professor at the University of California at Irvine, who died in 2012. “Sherry” received the Nobel Prize with Mario Molina and Paul Crutzen. They discovered that chlorofluorocarbons (CFCs) in aerosols could destroy the earth's protective ozone layer and thereby create a potentially grave environmental problem. There were many critics of the work – both from industry and academia – until it was vindicated and proven correct. Sherry successfully advocated for a ban on CFCs that was achieved with the 1987 Montreal Protocol Treaty. I worked with Sherry when he served as the NAS Foreign Secretary for eight years. He used science and technology and his worldwide reputation to advance relations between the U.S. and other countries. He was treated like a “rock star” when travelling overseas. He helped to create the InterAcademy Panel of science academies around the world, which fosters the scientific capacity of academies in developing countries.³ He

was a scientist who viewed scientific knowledge as a means for protecting our planet and improving lives of people everywhere.

Non-governmental institutions are also critically important to science diplomacy. The U.S. National Academies – which includes the National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council – collaborate bilaterally and multilaterally with scientific academies and scientific organizations around the world to provide independent, expert advice to governments and international organizations on important global issues. The goal is not only to make progress on solving problems that countries face, but also to help scientific organizations around the world become more important advisers to their governments.

The American Association for the Advancement of Science (AAAS) has created a Center for Science Diplomacy that has focused on scientific communication with countries where the U.S. government does not have diplomatic relations.⁴ The AAAS has engaged with North Korea and Cuba, and was among the first to engage with Burma. Both the AAAS and the NAS have engaged with Iran; in fact, the NAS has been conducting workshops and exchanges with the Iranian scientific community for over a decade. Science cannot break down all the barriers, but when a window of opportunity emerges in governmental relations, the existing scientific contacts can be a great asset, as was the case for U.S. relations with both China and Russia. The U.S. State Department has always encouraged our non-governmental scientific organizations to maintain contact and communications with scientists in countries where diplomatic relations do not exist.

Private foundations have also played a significant role. As an important recent example, the Howard Hughes Medical Institute (HHMI) has partnered with South Africa to create a fundamental science research center called KwaZulu-Natal Research Institute for

Tuberculosis and HIV (KRITH) in Durban to focus on solving the critical health problem of joint HIV and TB infections.⁵ Durban is the epicenter of this pandemic, and HHMI has committed over US\$ 70 million for KRITH. The research center works with the local university and hospitals in Durban and has attracted researchers from around the world. It has built considerable goodwill between the U.S. and South Africa. The Bill & Melinda Gates Foundation is another example of utilizing science to solve health problems facing developing countries, and has directed enormous resources and expertise at these issues. The foundation has provided support for a decade to the NAS and Institute of Medicine to help science academies in Africa to become more important advisers to their governments on health issues. The Humboldt Foundation, which was established by the German federal government, is another great example of an organization pursuing science diplomacy through collaborations in fundamental science and engineering. The many Humboldtians around the world are an important scientific network as well as a bridge between Germany and other countries.



“Science is ... an agent of change, is an equalizing force in society, works for the common good, and is a source of optimism about the future.”

Research universities in the U.S. and Germany are very international and build linkages between countries. The international collaborations are not only those initiated by individual faculty, but also strategic engagements made by university leaders and partly financed via university funds. It is hard to keep track of all the international engagements that our major research universities are undertaking. And it is important to remember that one of the greatest diplomatic initiatives of our two countries has been attracting the best and brightest from around the world for graduate education and research. This is something that the Humboldt Foundation does exceedingly well.





Science for good policy-making

In my conversations with representatives of other countries about the role of science and technology in society, there are two areas where I try to gently lobby. The first is to encourage every government to seek the independent advice of its non-governmental scientific community on public policy issues where scientific and technical insights are relevant. The goal is for a country to have high quality, objective, and credible scientific advice – free of politics and special interests, independent of government control, and conveyed to the public as well as to the government. In their decisions, political leaders necessarily incorporate value judgments and other considerations that go beyond science, but objective scientific advice may help lead to wiser decisions. It is in everyone's interest for all countries to have decisions informed by the best scientific information, conveyed transparently, without bias, and with accurate representation of scientific uncertainties.


The second area where I lobby is for governments to consider creating opportunities for young scientists, engineers, and medical professionals to experience working in government. My office is the steward of several outstanding fellowship programs that bring science and engineering PhDs to work at the State Department. Over 40 fellows sponsored by the AAAS are currently in their first or second year in the State

Department, and approximately 60 former fellows have become regular civil service or foreign service employees. Wherever I have gone at the State Department, I have found either current or former fellows. They have permeated the Department, greatly added to the science and technology human capacity, and formed a network outside of the hierarchy. The same is true for AAAS fellows working at USAID. The Jefferson Science Fellows Program, which was initiated by one of my predecessors eight years ago, brings senior tenured faculty to work for a year in the Department or USAID. Jefferson Fellows continue to serve as resource experts after returning to their universities. Twelve Jefferson Fellows are serving this year. Two professional societies – the Institute for Electrical and Electronics Engineers (IEEE) and the American Institute of Physics (AIP) – bring several fellows each year as well. My office is staffed almost entirely by current and former fellows. In fact, the current Assistant Secretary for the Bureau of Oceans and International Environmental and Scientific Affairs, Kerri-Ann Jones (who delivered a keynote at the 2010 Forum on the Internationalization of Sciences and Humanities), the current Science and Technology Adviser to the USAID Administrator, Alex Dehgan, and I are all former AAAS fellows. Fellows contribute to science diplomacy whether they stay in government or pursue careers outside of government.

The benefits of knowledge sharing

Science diplomacy helps other countries to become more capable in science and technology. One might worry that this creates more capable competitors, but I believe that it is in the interest of advanced countries like the U.S. and Germany to have more knowledge-based societies worldwide that rely upon science. The only way to stay in the forefront of the scientific and technological revolution, which is where I want the U.S. to be, is to run faster and to work with the best scientists and engineers wherever they reside in the world. That is why I support more global scientific engagement by the U.S. with leading scientists and engineers around the world. It is also why I like the Humboldt Foundation's philosophy of focusing on the best people in its funding decisions. The approach that I favor was captured well in the title of an article in the October 2012 issue of *Scientific American*: "A measure of the creativity of a nation is how well it works with those beyond its borders."

I believe that the world has a special opportunity in this decade since so many countries are focusing on improving their capabilities in science and technology and are willing to make fundamental changes in investments and policies so they can build more innovative societies. If we can minimize wars and conflicts with skillful diplomacy, the potential is there for more rapid economic growth, faster expansion of the middle class, and increased democratic governance in many countries as well as increased trade between countries. This is an optimistic scenario. A range of future scenarios, including some that are quite pessimistic, are laid out in the report "Global Trends 2030", published by the U.S. National Intelligence Council in 2012.⁶ I believe that we can make the hopeful scenario a reality. Science diplomacy is one of our most important tools in achieving the desired outcome.



"The only way to stay in the forefront of the scientific and technological revolution ... is to run faster and to work with the best scientists and engineers wherever they reside in the world."

Science as a shared value

Let me end with a sentiment that I learned from another mentor, Bruce Alberts. He is a distinguished biochemist at the University of California at San Francisco, former president of the U.S. National Academy of Sciences, former U.S. Science Envoy to Indonesia, and current editor of *Science Magazine*. He has emphasized that the values and ethics that come from doing science are congruent with democratic values. Both the scientific revolution and the democratic revolution grew out of the Enlightenment. Science values the individual, relies on freedom of inquiry and the entrepreneurial spirit, rewards excellence and merit, bases decisions on evidence, supports academic freedom, relies on peer review, and encourages transparency via publication. Science is also an agent of change, is an equalizing force in society, works for the common good, and is a source of optimism about the future. So the ultimate connection between science and diplomacy is shared values, which is the fundamental reason why science diplomacy is a strategic asset for democratic countries.

Bruce Alberts often quotes the great scientist-humanist Jacob Bronowski from lectures delivered at Harvard and published in the book "Science and Human Values" (1956). I will quote only one sentence among the many memorable lines in the book: "Men have asked for freedom, justice, and respect precisely as the scientific spirit has spread among them." ■

Quoted literature:

¹ www.nap.edu/catalog.php?record_id=11463

² www.nytimes.com/2012/03/20/books/the-idea-factory-by-jon-gertner.html

³ www.interacademies.net

⁴ diplomacy.aaas.org

⁵ www.k-rith.org

⁶ www.dni.gov/index.php/about/organization/national-intelligence-council-global-trends



Networks of Trust: Will the New Social Media Change Global Science?



On October 21 and 22, 2012, distinguished representatives of academia, science administration and research policy on national, regional and international levels, and other top-level international experts convened at the Akademie der Künste in Berlin for the 6th Forum on the Internationalization of Sciences and Humanities. Following an invitation by the International Advisory Board of the Alexander von Humboldt Foundation, they participated in an open and multifaceted exchange of ideas on the question “Networks of Trust: Will the New Social Media Change Global Science?”

The Forum offered several complementary events: Dr. E. William Colglazier, Science and Technology Adviser to the U.S. Secretary of State, opened the Forum with a keynote address based on his vast experience in and vision for science diplomacy. An international expert panel consisting of science policy experts and researchers in various disciplines and career stages discussed the opportunities, challenges, and limitations of “networked science”. Finally, several of the most important science organizations in Germany presented ideas and activities aiming at harnessing the potential of social media for the future of international research cooperation.







Riley Crane

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The Impact of Social Media and Networks on Research

Social media has transformed one of the oldest phenomena of humanity – social networking. By tapping the power of our collective intelligence, Web 2.0 technologies have revolutionized the way we exchange ideas, share data, and solve even the most challenging problems, reshaping research and academic cooperation along the way. | **By Riley Crane**



We are currently living through a technological revolution that is transforming the world as we know it, from business to government to society at large. These changes are being driven by the democratization of technology and new tools of social media, which are making it easier for anyone to interact and participate in a more meaningful way than ever before. I have spent the past six years of my life as a physicist working in the field of computational social science, studying how information spreads through social networks and how social media can be harnessed to solve global challenges. In the following overview I would like to illustrate what impact social media and networks might have on the future of scientific research and give some examples of how it is already making an impact now.

But first, let us take a moment to define what we mean by social networking and social media.

Science transformed

Most of us think of *social networks* as Facebook and Twitter, but the reality is that social networks have probably existed since the beginning of time. *Social networks* are really nothing more than groups of individuals connected by some commonality: relationships, beliefs, profession, or purpose. *Social networking* is the set of interactions amongst the individuals or groups within social networks. What Facebook and Twitter have done is to publish these interactions, making them more visible.

What then is *social media* and how does it differ from social networking?

Before the Internet and the World Wide Web, social networking typically occurred in person at real places like work, school, community centers, or conferences. Even when the Web took off in the late 1990s and early 2000, this was still how “networking” was done.

Around 2004 the Web started fundamentally changing. In the early days, the Web was about content publishing. People would make a website and put

things on it – articles, photos, links, etc. Every so often they would update it. But then Web 2.0 came along, and suddenly there were new ways to publish; content could be modified by all users and there were new tools for collaboration. This new “Web 2.0” is the platform on which all social media developed. We can therefore think of social media as defined on Wikipedia as *“a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user-generated content.”*

“Everything from how science is taught and how we discover new ideas and research, to how we find collaborators, how we publish findings, and how those findings are disseminated to the public and other peers should expect to be transformed.”

Viewed in this light, the answer to the question of how social media might transform science becomes obvious: A new platform in use by nearly every connected individual on the planet, with tools for the exchange of ideas, the creation of data, tools for debate, and publishing. This after all is what we do when we are doing science. It is only natural to expect that science will be transformed.

Everything from how science is taught and how we discover new ideas and research, to how we find collaborators, how we publish findings, and how those findings are disseminated to the public and other peers should expect to be transformed.





New contributors, a huge new audience

Some examples of the ways that this new social media has already begun impacting research:

- Science education: Social media is training new generations of scientists in new ways. The Khan Academy offers anyone with an Internet connection access to thousands of video lessons on everything from arithmetic and physics to finance and biology. Having served over 192 million lessons, they are changing the way the next generation of scientists will learn and practice math and science, especially in the developing world.

“We are training the next generation of scientists using the tools of social media. Many of them will enter the scientific workforce already fluent in the complexities of global collaboration.”



Major universities like MIT and Stanford have been opening up their courses to anyone in the world. You can now take graduate courses in “string theory” at MIT or take “Machine Learning” with 100,000 other individuals, offered by Stanford University. Suddenly the best education centers of the world are being opened to all, regardless of geography or socio-economic condition. As one of the founders of this movement recently said: “The next Einstein may be a little girl in Afghanistan who just needs the opportunity to access quality education.”

We are training the next generation of scientists using the tools of social media. Many of them will enter the scientific workforce already fluent in the complexities of global collaboration.

- Sharing scientific discoveries with the public: In 2008, CERN, the European Organization for Nuclear Research and birthplace of the Web, was bringing the world’s largest particle accelerator – the Large Hadron Collider – online. Around the same time they created the lab’s Twitter account. CERN is a publicly funded institution, and when asked why they use Twitter, the director of communications replied, “Engaging with the public, who pays the bills, is very important.”

When it was time last July to announce the discovery of the Higgs boson, CERN did not host an exclusive press event. Instead, live video was streamed across the web; questions were taken not only from journalists, but also from Twitter followers.

In the four years since they joined Twitter, their account has reached nearly 700,000 followers. Social media has given these scientists a much larger audience to engage with and allows them to explain the impact of their work with the broader public.

- Sharing with the scientific community: While involving and educating the public is certainly important, the possibility of reaching a broader scientific audience of one’s peers is even better. The progress of science depends upon the exchange of new ideas and discoveries. That’s why we publish and attend conferences. With the Internet, it is now possible to publish a scholarly work and make it instantly accessible almost anywhere in the world.

Can Open Access make science better?

Ironically however, just as technology is making universal unlimited access a real possibility for the first



time in history, we are dealing with decreased access as a result of increased costs – many libraries and individuals can simply no longer afford it. This struggle has given rise to the “Open Access” movement – the practice of giving unrestricted access via the Internet to peer-reviewed scholarly journals. This movement is a direct challenge to a traditional journal publication’s way of doing business. While Open Access faces many challenges and critics, the central question on the table is whether or not it can develop a system that takes the core goals of scientific publication – critique by expert colleagues and transmission of results to a large group of peers – and do them better.

Here it seems that Open Access’ intimate relationship with social media might give it the edge against its older, more traditional competitor. Social media by its very nature brings increased debate and transparency. Many researchers have already taken to promoting their work through Twitter, Facebook, and blogs; these channels have large dedicated followings and new research receives timely feedback and sparks rich debate, ensuring that relevant work is less likely to go unnoticed. As open publishing platforms emerge, alternatives to peer review may gain acceptance, and some have speculated that the old motto of “publish or perish” may be transformed into “get visible or vanish”.

Global brainstorming

While the developments described so far are impressive, the most exciting changes being driven by social media are around new models of collaboration. Researchers from around the world have started engaging with each other and with the public in new ways to tackle problems that once seemed intractable.

For example in 2009 Tim Gowers, a British mathematician and Fields Medal recipient, reached out to the readers of his blog and asked for their ideas and help at solving an important and difficult problem in mathematics (the Hales-Jewett theorem). The title of his post: “Is massively collaborative mathematics possible?” In it, he asked whether large numbers of people could work together to solve a problem that did not naturally split up into a vast number of subtasks. His idea was to create a forum where anyone could chip in.

“Social media has given these scientists a much larger audience to engage with and allows them to explain the impact of their work with the broader public.”

The ethos was to keep contributions short – instead of spending a month thinking hard about the problem and submitting a 10-page essay, people were encouraged to contribute ideas that were undeveloped and even likely to be wrong. Seven weeks after pondering this approach it was announced that the problem they set out to work on was solved. They have since launched seven other polymath challenges and the group has produced many publications.

The power of the people

While this illustrates the role that social media can play in shaping how *experts* collaborate, open collaboration has also been used to solicit the help of the general *public* in solving problems. In 2007, a site called GalaxyZoo launched using a dataset made up of millions of galaxies from the Sloan Digital Sky Survey. The challenge was to classify the shapes of these galaxies – were they elliptical, merger, or spiral, with various possible sub-classifications. Within 24 hours of launching the site, GalaxyZoo was receiving



over 70,000 classifications per hour. Over 150,000 individual contributors completed more than 50 million classifications in the first year. It was shown that these amateur classifications were as good as those from professional astronomers, and the site has generated over 20 peer-reviewed papers.

But what about problems requiring true expertise? Predicting the conformational structure of proteins is important for biologists and medical researchers to design novel proteins and treat new diseases. It is an incredibly challenging problem requiring complex computational models rooted in a deep understanding of biology and physics. Given a protein structure there are billions upon billions of possible stable configurations that a protein can choose and yet everyday, the proteins in our bodies solve this incredibly challenging problem almost effortlessly.

“Social media levels the playing field, allowing experts, non-experts, people working in different fields, isolated by geography, to work together to solve problems that were previously intractable.”



In 2008, a group of researchers developed a program called Foldit – a collaborative 3D game in which players attempt to wiggle and twist a complex simulation of a real-world protein and get points whenever the physics of their solutions lowers the overall energy of the configuration. Foldit took a domain that was previously confined to the work of a few highly trained, highly skilled experts, and democratized it, lowering the barrier to entry using a virtual game-world and the tools of social media. Before Foldit, the same researchers relied on a crowdsourced system called Rosetta@home that would borrow spare computing cycles from an individual’s computer to help solve the problem computationally and show the solution progress as a screensaver. Many users of this became frustrated when they could see ways of solving protein structures themselves, but had no way to interact with the program, and Foldit was born when the

researchers realized people might be much better than computers. In 2011 gamers playing Foldit solved – in 10 days – a protein structure that had stumped scientists for over 15 years, amongst other notable successes.

Value and validity

These new models of collaboration would not have been possible before the advent of social media. Social media levels the playing field, allowing experts, non-experts, people working in different fields, isolated by geography, to work together to solve problems that were previously intractable. Finally, in addition to everything we have discussed, social media itself has become a subject of science because of the new opportunities presented by the “large archives of naturalistically-created behavioral data.” As the topic of this forum betrays, we live our lives in the network. We check our email, mobile phones, use our transit cards for public transport and our credit cards to make purchases. All of these day-to-day activities leave traces, a sort of digital exhaust that can be compiled into comprehensive pictures of who we are as individuals and as a society, and a new science is emerging around these questions.

For all of the opportunities presented by social media, there are many challenges. In this new world it may be difficult to gauge an individual’s contribution. The validity, value, and authority of much research used to depend upon the filters of higher education; as more amateurs and non-experts have tools for contributing it will be more important to develop systems for assessing the value and validity of such research.

Social media offers the promise of letting us accomplish more, much faster, with fewer resources. What new problems can we solve when we develop methods to bring together the collaborative might and mind power of our peers and society at large? We are in the early days of this exciting new world, and I for one believe that the future looks bright. ■

**Mark A. Suskin**

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Science 2.0 and Research Funding: The Potential for Research Organizations to Pave the Way

Cyberinfrastructure has fundamentally changed the way science is done, and as **Mark A. Suskin** of the National Science Foundation sees it, the onus is now upon the world's funding agencies to support the science community in defining its cyberinfrastructure needs in a pioneering spirit of openness and experimentation.





I come to you today with the thesis that cyberinfrastructure is changing the way science is done, and that the agencies whose responsibility it is to support science must be prepared to adapt, otherwise they will diminish in their effectiveness in meeting that responsibility. As Deputy Head of the National Science Foundation's (NSF's) Office of Cyberinfrastructure, I have both a strong personal and official interest in this topic.

“Nature has no respect for the separate fields of science. Solutions to the problems nature presents to us require all the sciences together, and the sharing made possible by cyberinfrastructure will come to be a requirement of good science.”



When I speak of cyberinfrastructure, I am referring to high-performance computers, data repositories, networks, the software that makes those systems function, as well as the software that scientists use when addressing scientific questions. To include those items in cyberinfrastructure is fairly common. But I have come to see that there is a human aspect of cyberinfrastructure that must be accounted for, if cyberinfrastructure is to be all it can and do all it can for the scientific community.

That human aspect has to do with how the community decides what cyberinfrastructure it needs and how it communicates those needs to the funding agencies that must, particularly in times of constrained resources, make decisions about what to fund and what not. Ironically, cyberinfrastructure itself may play an important role in the answer to those implied questions. Can cyberinfrastructure help the science community

self-organize to come to consensus about its cyberinfrastructure needs, and can it help with gathering and analyzing the signals from a large, diverse, and widely dispersed group of scientists which is the raw data for the consensus?

I believe the answer is Yes, but I think making the process a reality must now become a primary responsibility of funding agencies, and I think it is going to take a great deal of adaptability as well as a lot of experimentation to find the mechanisms that work best. Making the necessary changes will require rethinking what the goals of a funding agency are, what internal organization will best serve those ends, and even what the staff should be spending their time on.¹

Cyberinfrastructure and “the new science”

Let me first talk about how it is that cyberinfrastructure is changing the way science is done and then I will talk about what funding agencies need to pay attention to in order to keep up with the change.

I think the days when a scientist will work alone are soon to be gone. Not that he or she cannot go into an office, shut the door, and calculate, but the interconnectedness is now so broad and the transmission of information so rapid, that the results of that solitary work can be and, for the good of science, should be available to other scientists everywhere almost immediately.²

Now that scientists are able to share more easily, science, that is, the new science, will evermore *require* that they share, and not just the results of calculations



and experiments, but data and software as well. More and more, scientists will be sharing as they are working, and working on ways to share – so that the understanding of the need to share will alter the way they do their science, write their software, take and store their data. And this is as it should be, since nature has no respect for the separate fields of science. Solutions to the problems nature presents to us require all the sciences together, and the sharing made possible by cyberinfrastructure will come to be a requirement of good science.

Now if it is true that the new science will be more a shared endeavor than ever before, the question for funding agencies is how to support and even accelerate movement in that direction. The specific question for my part of NSF is, “How do we support the laying down of cyberinfrastructure that both responds to the present and future needs of the research community and leads them in the right direction?” The answer to that question turns out to have more to do with sociology and community politics than I would ever have imagined. For me, the most interesting aspects of the answer have more to do with how humans interact than with how to fund hardware.

An experiment in adaptability: NSF’s EarthCube

I think what funding agencies have to do is to find new ways of speaking and listening to the science community with regard to what cyberinfrastructure is needed. I am going to refer now to a specific experiment currently being tried at NSF. It is called EarthCube; it was initiated 15 months ago in June 2012 by the Directorate for Geosciences together with my office;

and its stated goal is to design and implement the cyberinfrastructure necessary for scientists studying the earth system to address scientific questions holistically. Traditionally, earth scientists, ocean scientists, and atmospheric scientists have worked more independently than together. They consider themselves to be working in separate disciplines, with separate methodologies, separate tools, and even separate vocabularies. So you can see immediately that the direction of EarthCube represents in miniature what I stated above as the direction of science as a whole.

“No one disputes that the funding agencies should support advances in cyberinfrastructure itself, and I believe we have an added responsibility to support the community in the design of an optimal cyberinfrastructure – optimal for the scientific enterprise as a whole.”

Fifteen months ago, we knew what we wanted to end up with (namely a cyberinfrastructure appropriate for all the geosciences), but had little idea how to get there. Our first step was to inform the community by letter and via webinar what it is NSF was trying to accomplish. We then held a “charrette” in October 2011. A charrette, as the name implies, is a French cart, pushed by hand, that architects in France would use to lay out and compare their designs for a building. That was exactly the purpose of the October meeting: to bring members of the various communities together to discuss how to proceed in order to develop a design for the desired overarching cyberinfrastructure. There are tens of thousands of geoscientists, but the charrette could accommodate at most 200. How to choose? How to ensure proper representation?





Let me pause for a moment on the representation issue, since I think it is one of the most interesting and important of the issues raised by EarthCube. How do tens of people represent thousands of people? That, to me, is a political question, and if it is not dealt with properly, it would be easy to have the loudest voices and biggest players end up in the room. But how representative would that be? And if we are not representing the full breadth of ideas in the community, it is a good bet that the cyberinfrastructure resulting from our process will not be optimal. As a sidelight, what came to my mind was the necessity for a kind of

“The best way to govern the process of creating a cyberinfrastructure for the future is not known, so the more experiments we have going on, the better ... I see a brave new world in the offing, and I would welcome company in finding the way there.”



system where local groups each choose a representative to a set of larger groups, which each chooses a representative, and so on, thereby ending up with the 150 or so that can fit in a room and discuss future plans.

But of course, NSF cannot and should not do everything for the community; the community itself must take charge. The way I see it, the community must organize itself. NSF's role is to provide the nuclei around which that self-organization can take place. But many of the things that need doing are turning out to be different from what NSF typically does. After the charrette in October 2011, we invited the community to submit proposals for up to US\$ 300,000 each to come up with designs for different pieces of the future geosciences cyberinfrastructure. We got about 65 proposals of which four or five were worthy of funding.

Normally, NSF would decline the remaining proposals. But because we noticed that the proposals “clumped” around four or five topic areas (ontology, governance, workflow, etc.), we decided to offer the relevant proposers the opportunity to get together with other proposers in the same topic area and submit a new proposal for a “community group” to be responsible for that topic area. One specific charge for the community groups was to find ways to gather input from a broad swath of the community (since NSF continues to be concerned about the representation issue).

The point is that much of what we are doing as part of EarthCube is new to NSF. We did not even know the word “charrette” until last year. NSF never changes the rules in midstream, but we did when, instead of declining proposals, we offered the proposers funding if they would band together to address clearly relevant topic areas. And the new ways of doing business are still being instituted as we go along, and that will not cease as long as EarthCube continues. We spent US\$ 6 million on EarthCube in fiscal year 2012, and plan to spend at least US\$ 19 million in fiscal year 2013, which began October 1.

Shaping the future of science together

So let me bring this to a conclusion by restating my two-part thesis that cyberinfrastructure is changing

the way science is done and that science funding agencies are going to have to adapt in order to support the community properly. I believe that computational and networking capabilities have brought us to a juncture unheralded in the history of science. Scientists will be able to work across fields in ever more productive ways, making the most difficult cross-disciplinary questions about nature amenable to solution. I believe that same infrastructure will allow for new modes of communication among scientists and between the scientific community and funding agencies. No one disputes that the funding agencies should support advances in cyberinfrastructure itself, and I believe we have an added responsibility to support the community in the design of an optimal cyberinfrastructure – optimal for the scientific enterprise as a whole.

For those in the audience who agree with me about the future of science, I ask you to join in this exciting foray into the future. The best way to govern the process of creating a cyberinfrastructure for the future is not known, so the more experiments we have going on, the better. I invite other funding agencies to work with us in NSF to try different approaches, look for new mechanisms, and interact with the research community in new ways. I see a brave new world in the offing, and I would welcome company in finding the way there. ■

Remarks:

¹ As a case in point, NSF Program Officers are swamped with work – over the past decade and a half the number of proposals NSF receives has increased by 50 percent, but the number of Program Officers has remained constant. In order for them to take on the challenges presented by the changing way science is being done, something must be done to free up time for that. I see no way to do that without looking into ways to reduce the current burden that proposal review places on them.

² When I was in physics graduate school in the 80s, I would do my calculations, write a paper, send it to a journal, wait several weeks for the reviewers’ comments, respond to the reviewers’ comments, and

wait several more weeks to see the paper published. When, less than a year ago, I read of the experiment that measured neutrinos traveling between CERN and Gran Sasso at speeds greater than the speed of light, I was able to see a preprint of the experimenters’ paper within a week. It had not been subjected to review, but there it was. I must say, I found it daunting because I was looking for a mistake in their method, but it seemed to me they had done a pretty thorough job of things. I figured the most likely thing was that they had measured the distance incorrectly, but their exposition of the GPS system they used seemed airtight. As it turns out, they did measure the distance incorrectly – which is good because now I do not have to relearn all of my physics.



Romain Murenzi

Executive Director of TWAS, the academy of sciences for the developing world, and former minister of science & technology for the government of Rwanda

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A Virtuous Cycle: Building Science Capacity through Academic Networks

This year TWAS, the academy of sciences for the developing world, celebrates 30 successful years of scientific capacity and excellence building in the South. The academy's director **Romain Murenzi** presents its formula for becoming the world's largest South-South academic network for sustained development and global progress.

Developments, inventions, and innovations in science and technology have the power to address global challenges such as climate change, food and energy scarcity, biodiversity loss, and population growth. In addition, scientific innovations can also generate income through product development and patents. But it is neither easy nor straightforward to establish programs in science, technology, and innovation in developing countries. To do this effectively requires networks of individual researchers and research institutions based throughout the South, as well as a more global network of partners and sponsors. This is what TWAS, the academy of sciences for the developing world, has been doing successfully for the last 30 years.¹

In developing countries, performing the functions necessary for day-to-day living can be complicated: Water often is in short supply, travel can be difficult, power for cooking or lighting can be intermittent or non-existent, and even when there is electricity, a lack of broadband coverage can impose profound limits on Internet access. The likelihood of contracting malaria or other deadly diseases and not receiving adequate treatment is high.²

Imagine the challenges of this environment for those who want to undertake serious scientific research. From a practical point of view, if you provide young researchers with the means to travel to academic institutions that not only have adequate power supplies, but may also provide full board and accommodation, their work is bound to improve. If, in addition, you provide good or even state-of-the-art facilities and a group of dynamic researchers all working in the same field, the students' ability to do excellent scientific research will increase substantially.

TWAS has established, over the last three decades, a series of very strong academic networks that enable researchers based in the South to do exactly this: to do their work, to achieve standards of excellence, and to pass their knowledge on to others in their home countries so that research groups can develop and become established.

TWAS is a global academy

Many nations have national academies, but TWAS is a global academy. It has grown from 43 founding members to 1,077 elected members today, of whom 85% come from developing countries. Through its members, TWAS has built a worldwide scientific network that includes academies of science, research councils, universities, and research institutions. Through this network, TWAS has built up relationships with a series of partners, particularly in countries with emerging economies such as Brazil, China, and India, in order to administer PhD and postdoctoral fellowship programmes, for example.

But TWAS's influence also depends on two other crucial networks: our five regional offices, and centres of scientific excellence throughout the South. While the administrative headquarters of TWAS are in Trieste, Italy, our regional offices in Brazil, China, Egypt, India, and Kenya help ensure that our programmes and activities reach the right people. These offices are hosted either by national academies, such as the Brazilian Academy of Sciences in Rio de Janeiro, the Chinese Academy of Sciences in Beijing, and the African Academy of Sciences in Nairobi, or by renowned institutes of scientific learning and research such as the Jawaharlal Nehru Centre for Advanced Scientific Research in Bangalore and the Bibliotheca Alexandrina in Alexandria.

“In developing countries, performing the functions necessary for day-to-day living can be complicated: Water often is in short supply, travel can be difficult, power for cooking or lighting can be intermittent or non-existent ... Imagine the challenges of this environment for those who want to undertake serious scientific research.”

TWAS Regional Offices are well placed to be involved in the recruitment and selection process for our research fellowships, grants, and prizes and are responsible for organizing local conferences and meetings.





Centres of scientific excellence

TWAS has researched and published a series of profiles on selected centres of scientific excellence, such as the Okavango Research Institute in Botswana, the National Institute of Biodiversity in Costa Rica, and the International Centre for Biological and Chemical Sciences in Pakistan.³ In addition, TWAS has published a book providing profiles of 485 such scientific institutions in 65 dif-

“Without a critical mass of professors with doctorate-level research experience, there is no way a country can build up a base of scientific knowledge or ensure that the latest developments are passed on to teachers and students.”

ferent countries in the South, outlining their main scientific achievements, facilities, and future plans.⁴ TWAS works with many of these institutes, recommending them to research students and visitors who are awarded TWAS fellowships and other exchange opportunities.

With these crucial networks in place, TWAS is able to administer and coordinate a series of programmes to effectively build scientific capacity in the South. Without a critical mass of professors with doctorate-level research experience, there is no way a country can build up a base of scientific knowledge or ensure that the latest developments are passed on to teachers and students. TWAS administers and co-sponsors

the largest South-South fellowship programme in the world. We currently offer about 360 fellowships per year, including 170 PhD fellowships, as well as postdoctoral, research, and advanced training fellowships.

The TWAS fellowship programme currently has 14 partners in nine countries in the South (Brazil, China, India, Iran, Kenya, Malaysia, Mexico, Pakistan, and Thailand). The partners cover the costs in the host country, including stipend and accommodation, while TWAS covers travel, visa, and administration costs.

TWAS is now campaigning to dramatically increase the number of these PhD Fellowships to 1,000 per year⁵, meaning that over the next 15 years, there could be up to 20,000 new researchers trained to PhD level and beyond throughout the South.

Human capital mobility

Too many eager and young scientists are being deprived of opportunities, stimulation, and challenges. TWAS provides opportunities for scientific exchange with colleagues in technologically advanced countries and with emerging countries. In addition to PhD fellowships, we offer:



- South-South postdoctoral fellowships
- South-North visits from Sub-Saharan Africa to Germany
- A TWAS-UNESCO associateship scheme
- TWAS research professors and visiting scientists exchange programmes, and
- Support for scientific meetings held in developing nations.

For example, through our partnership with UNESCO, an associate (who must be a scientist living and working in the South) is appointed for three years and can visit a centre of excellence in the South twice during that period. TWAS provides travel support and a subsistence contribution (US\$ 300 per month), while the host centre provides living and laboratory expenses. More than 100 centres have joined this initiative. Between 2007 and 2011, TWAS sponsored 135 associates.

We provide merit-based research grants for scientists in the South to continue their studies, or to acquire the essential laboratory or technological equipment that they need. At the end of the grant, the infrastructure remains the property of the university.

Grant holders can also apply for a second stage of further funds. The Research Grants programme has been an extremely effective means of encouraging clusters of research in specialist areas and spawning research groups.⁶ Between 1986 and 2011, TWAS awarded a total of 2,024 research grants worth US\$ 11 million.

TWAS' strong South-South networks bring many advantages

TWAS prizes are given for significant contributions by scientists living and working in the South. Our prizes range from highly prestigious awards for scientists who have contributed many years of research to developing countries, including the Ernesto Illy Trieste Science Prize worth US\$ 100,000, which ran annually from 2005-2012, to the TWAS Prizes in nine areas of science, recognized as among the highest accolades given to scientists in developing countries. Prizes are also awarded to researchers at the early stages of their careers.

In addition, TWAS works with the Organization for Women in Science for the Developing World (OWSD)⁷, a network of some 4,000 women scientists, the majority of whom are in the South. In 2012, with OWSD and the Elsevier Foundation, TWAS launched an award to celebrate the achievements of early-career women scientists.⁸



“Researchers who have received grants and awards from TWAS ... have then gone on to establish their own laboratories and train a new generation of students. These students, in turn, will also have the opportunity to pursue the programmes and awards that TWAS offers. This becomes a virtuous cycle of knowledge.”



In conclusion, TWAS's strong South-South networks bring many advantages:

- **Economic.** When students and researchers move between developing nations, the costs of tuition are dramatically lower; visa clearance and administration can be simpler.
- **Cultural.** The culture shock can be less dramatic and subsequent adaptation can be easier, meaning that researchers, scholars, and students are more likely to persist in their research for the duration of the course.
- **Geographic.** The relevance of the science undertaken can be higher when countries share similar geographical or climate-related characteristics. For example, Aline Edith Mekeu Noutcha travelled from Nigeria to the Malaria Research and Training Centre in Mali to complete necessary experiments so that she could return home to continue her work.⁹

- **Resources.** Developing countries work with similar economic and other constraints. But exchanges of people lead to the exchange of knowledge: Researchers moving from one country in the South to another can bring with them valuable resources and results (e.g., bringing samples from Bangladesh to be examined with sophisticated equipment in Argentina¹⁰).

- **Intellectual.** As a condition of receiving a TWAS fellowship or other awards, the researcher is required to return home. Not surprisingly, these researchers are then in great demand in their home countries and often go on to build up their own research groups.

These are some of the networks developed by TWAS and many partners that have so effectively helped to build scientific capacity in the South. We have many success stories to tell of researchers who have received grants and awards from TWAS and who have then gone on to establish their own laboratories and train a new generation of students. These students, in turn, will also have the opportunity to pursue the programmes and awards that TWAS offers. This becomes a **virtuous cycle of knowledge**.

This is what it means – in practice – to build science capacity through academic networks. ■

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The International Advisory Board

The Alexander von Humboldt Foundation is a non-profit foundation established by the Federal Republic of Germany for the promotion of international research cooperation. It enables highly qualified scholars resident outside of Germany to conduct extended periods of research in Germany and supports subsequent academic contacts. The Humboldt Foundation promotes an active, world-wide network of scholars. Providing individual sponsorship during periods spent in Germany and fostering the resulting longstanding contacts have been hallmarks of the foundation's work since 1953.

The International Advisory Board of the Alexander von Humboldt Foundation is an independent, international expert group which meets once a year to discuss strategic issues relating to the global mobility of researchers and the internationalization of research. The Board provides a forum for debate on global developments in science and academia, science policy, and science administration.

History and mission

The International Advisory Board was established in 2007 in response to an increasing demand for expertise in questions concerning the internationalization of science and scholarship. It is a successor to the Advisory Board of the Foundation's Transatlantic Science and Humanities Program (TSHP), which was established in 2001 with the aim of creating a binational network of experienced leaders from German and North American academia, science administration, and science policy.

The International Advisory Board supports the Foundation's strategic planning. As an independent expert group, it addresses current developments in global academic markets and identifies topics of special strategic concern for the Foundation and its partners in Germany, the United States, and beyond.

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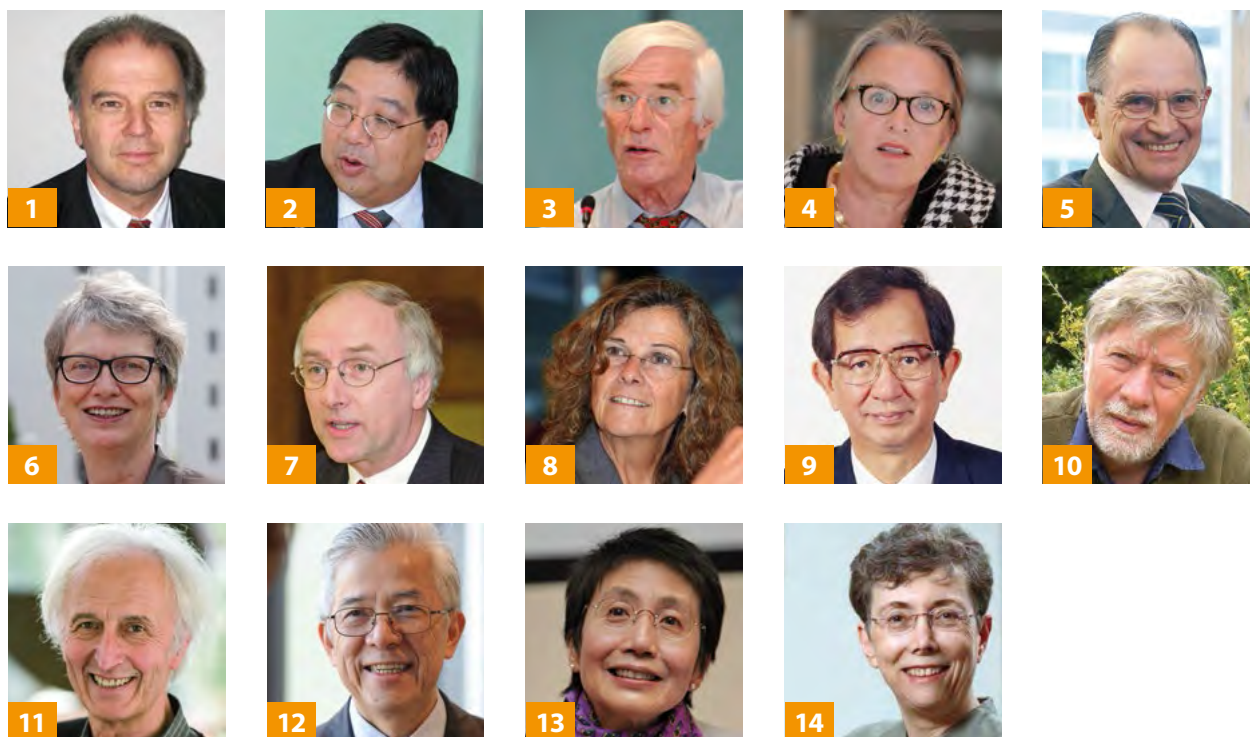
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Forum on the Internationalization of Sciences and Humanities

The International Advisory Board hosts the annual Forum on the Internationalization of Sciences and Humanities, opening its discussions to a select group of leading international experts and top management officials representing the Humboldt Foundation's partner organizations. Each Forum provides an opportunity for eminent international experts to hold an open exchange of views in a private setting. Important minutes of the proceedings and recommendations are published for the benefit of a wider audience.

Forum Topics

- 2001** The Role of the TSHP Advisory Board in the Transatlantic Dialogue
- 2002** Trends in American & German Higher Education
- 2003** The Impact of the New Developments within the European Research Area for Transatlantic Scientific Co-operations
- 2004** What Factors impact the Internationalization of Scholarship in the Humanities and Social Sciences?
- 2005** Bi-national Programs on Shifting Grounds?
- 2006** The Advancement of Excellence
- 2007** Postdoctoral Career Paths
- 2008** Strategies to Win the Best: German Approaches in International Perspective
- 2009** Cultures of Creativity: The Challenge of Scientific Innovation in Transnational Perspective
- 2010** Crossing Boundaries: Capacity Building in Global Perspective
- 2011** The Globalization of Knowledge and the Principles of Governance in Higher Education and Research
- 2012** Networks of Trust: Will the New Social Media Change Global Science?
- 2013** Postdoctoral Career Paths 2.0 – The Golden Triangle of Competitive Junior Investigators, Adequate Academic Systems, and Successful Careers

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