B. TAFRESHI/ESO

The Atacama Large Millimeter/Submillimeter Array (ALMA) telescope in Chile is a massive collaborative effort between many countries.

Global challenges need global solutions

Subra Suresh sets out the institutional reforms needed for collaborative action among international research–funding agencies to tackle the challenges humanity faces.

The challenges confronting global decision-makers are growing in complexity, intensity and urgency. Environmental change, pandemics, natural disasters, nuclear catastrophes, displaced populations, water shortages, rising ocean levels and widespread malnutrition do not stop at national borders or the water's edge. Addressing such issues requires cross-border cooperation and pooled resources.

Fortunately, the rapid growth in research capability around the world provides a strong foundation for finding science and engineering solutions to global challenges. Convinced that frontier research and technological innovation will spur strong economic growth, more and more countries are committing substantial sums to science and engineering research and education. Collectively, global investment in research and development has doubled within the past 15 years to about US\$1.4 trillion annually (amount adjusted for purchasing-power parity)^{1,2}, even through the turmoil created by the global financial crisis.

I am convinced that greater collaboration will maximize the effectiveness of those investments. Without a coordinated global response, humanity will not overcome the challenges it faces. That is why I

have strongly supported the efforts of the US National Science Foundation (NSF) to harmonize global research initiatives among science-funding agencies.

FOUR RECOMMENDATIONS

What are the barriers to cross-border scientific collaboration? One is the current framework for investment in research and development. Funding is governed and constrained largely by national and local policies, processes and priorities. These frequently impede cooperation among different government agencies, institutions and individuals. There are many more. For example, scientific peer review needs to be consistent across borders. Scientists need to be assured that data generated through cross-border collaborations meet certain standards of quality and research integrity, and that they will be preserved and accessible to other researchers — and the public — in the future. There are issues of intellectual-property rights, and constraints on the mobility of scientists.

Removing these barriers will require proactive principles and policies, developed and implemented collectively. To this end, I have four recommendations.

Standardize the principles for merit review and research integrity. Every funding agency needs a transparent, impartial and consistent peer-review process to pick the most scientifically productive ideas and people in the most ethical way. The patchwork of review processes currently in use in different countries is hindering scientific progress. Consequently, there is growing enthusiasm about, and commitment to, coordinating efforts to improve peer review from many science-funding agencies and other organizations in government, education, and the charitable and private sectors, in both developing and developed countries.

To support this, the Global Research Council (GRC; www.globalresearchcouncil.org) was established in May at the NSF, bringing together leaders of key science-funding organizations. At its inaugural meeting, some 50 heads of research councils — mostly from countries within the G20 and the Organisation for Economic Co-operation and Development — collectively

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developed a set of principles for effective merit review. These set out six key ingredients: expert assessment, transparency, impartiality, appropriateness, confidentiality, and integrity and ethical considerations. The GRC statement reads: “Rigorous and transparent scientific merit review helps to assure that government funding is appropriately expended on the most worthy projects to advance the progress of science and address societal challenges.” The fact that so many of the world’s leading science-funding agencies voluntarily and unanimously endorsed such a public statement is a crucial step towards increasing collaborative transnational research agreements.

Share resources to increase the scope and global impact of scientific experimentation.

Multi-user facilities enable important scientific discoveries by maximizing resources at a time when many countries face economic constraints. Astronomy offers many examples of how this approach works. In the 1950s, the NSF led an effort to ‘democratize’ the field by establishing national observatories. Today, radio, optical and solar telescopes around the world serve thousands of scientists and students. Consider the Very Large Array radio telescope built by the NSF in 1980. More than 2,500 scientists from around the world have used this telescope for more than 13,000 projects. Within the past decade, a partnership between funding bodies in North America, Europe and East Asia, in cooperation with Chile, developed and built the Atacama Large Millimeter/Submillimeter Array (ALMA) telescope, which is already a testing ground for theories of star birth and stellar evolution, galaxy formation and evolution, and the evolution of the Universe itself.

Another model for focused global interaction is CERN, Europe’s particle-physics laboratory located near Geneva, Switzerland. Discoveries here, such as the potential identification of the elusive Higgs boson, have been made by collaborations among scientists and funding from government agencies in many countries. Two further initiatives deserve mention. The Science Across Virtual Institutes project, launched by the NSF, promotes collaborations in research and education between NSF-supported research communities in the United States and many overseas partners. And the NSF has teamed up with the US Agency for International Development to form the Partnerships for Enhanced Engagement in Research programme, which supports collaboration between scientists in developing countries and in the United States.

A crucial element of international arrangements for scientific collaboration is the need for long-term commitments. Every effort should be made at the outset to support infrastructure and operating expenses, and to develop contingency plans for unexpected

shortfalls in funding. Such shortfalls, often caused by economic downturns, have detrimental effects on global science, with a loss of initial investments, loss of momentum in executing the research and the erosion of trust and goodwill among partners.

Explore new ways to share the research output of major scientific infrastructure projects.

Given that scientific credit is measured by priority, publications and patents, collaborative research output should be shared among all involved. The Antarctic Treaty is a model here. Under the treaty, the 28 consultative parties provide scientists with logistical support and operational and laboratory facilities in the Antarctic. Research observations and results from scientific work in the Antarctic then have to be made freely available to everyone.

A similar example of international collaboration is being implemented in parallel with the final stages of construction of ALMA. The ALMA Correlator — one of the world’s fastest special-purpose supercomputers — is already providing astronomical images for users on several continents. Ultimately, research data acquired from ALMA will be available to all, giving researchers around the world the chance to benefit from this scientific infrastructure.

Develop policies and mechanisms to guide the collection, analysis and distribution of ‘big data’.

Over the past few years, new scientific instrumentation, computational hardware and software, and theoretical analysis have markedly increased the sophistication, resolution, reach and scope of data collection, generating huge data sets. For example, the Large Synoptic Survey Telescope — a partnership involving the NSF, the US Department of Energy and private, educational and international contributors — will probe dark energy and dark matter, inventory the Solar System, explore the transient optical sky and map the Milky Way. It is expected to generate tens of terabytes of data per day.

Such volumes of data have to be organized, manipulated, integrated, distributed and stored — a process that poses major challenges. Together, funding agencies, research institutions and scientists must develop new ways to extract useful knowledge from mountains of information. Funding agencies must support studies of data gathering, access and storage so that information creation does not streak too far ahead of information curation. Policies must be formulated to ensure the privacy and confidentiality of sensitive data, and to safeguard intellectual-property rights and cyber security.

BETTER TOGETHER

These four steps require policies to promote the greater mobility of researchers, especially young scientists and students, across international borders. And there are further questions that the GRC and other international bodies are beginning to address, and which demand well-coordinated international efforts. For example, who will craft policy and ensure compliance for the benefit of the global scientific enterprise? How will the increased interconnectivity of individuals and institutions alter the dynamics of the global enterprise for knowledge generation? And how will institutions and individuals — from nations with very different histories, levels of research experience, financial resources, individual freedoms, priorities and laws — participate in a global enterprise while addressing national and local needs?

The future of science will be influenced by the interconnectivity of governments, research and educational institutions, and individual citizens around the globe. Integrating different perspectives will alter, energize and enrich science.

But policies for new modes of collaboration have implications that go beyond scientific progress. How the science and technology community organizes itself for the global era may determine how effectively humanity can tackle major societal challenges. The increasing integration of social, behavioural and economic sciences with the natural sciences and engineering will be essential in this regard.

I am encouraged by the energy, enthusiasm, commitment and seriousness of the members of the GRC. They represent an expert, interconnected global research enterprise that has decision-making authority, recognizes funding constraints and shows a genuine desire to engage developed and developing nations in the advance of global science. The next meeting of the GRC will be co-hosted by Brazil and Germany in Berlin in May 2013 (go.nature.com/wtgam1). It aims to endorse principles of research integrity and to begin to develop common policies and guidelines for implementing open access to scientific publications and data. Significant progress in these areas will have major implications for government funding agencies, for the researchers they support, and for all the people who will benefit globally from the results of these endeavours. ■

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