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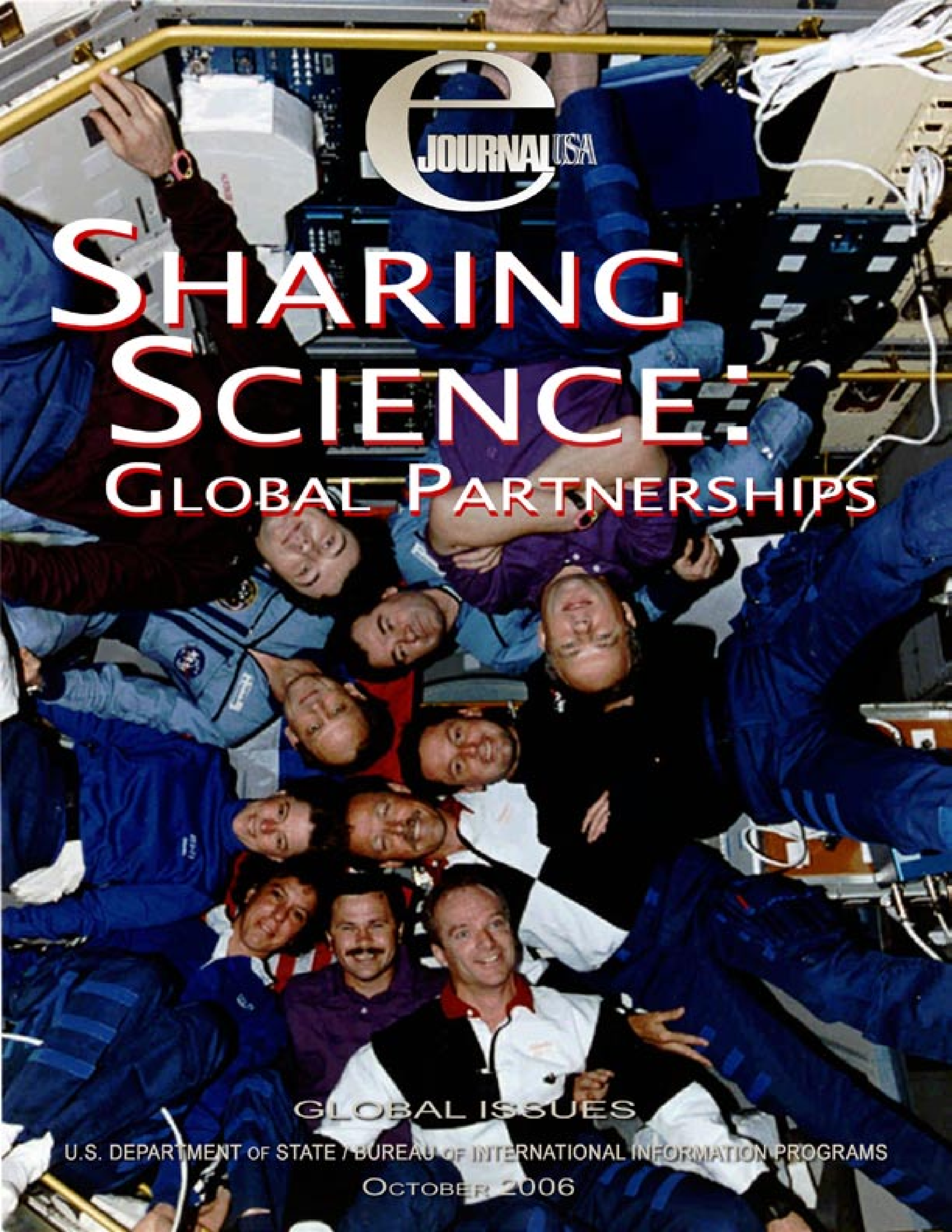
SHARING SCIENCE: GLOBAL PARTNERSHIPS



GLOBAL ISSUES

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Cover photo: Crew members of space shuttle mission STS-71, *Mir*-18 and *Mir*-19 pose for an inflight photo in the Spacelab science module in June 1995. Developed by the European Space Agency, Spacelab was mounted in the cargo bay of NASA's space shuttle and carried to orbit, where scientists explored many fields of science. Courtesy of NASA.

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About This Issue

Science is the source of innovations that improve public health, lighten the burden of labor, improve energy efficiency, and expand human understanding of the cosmos and the living world.

Science is also an inherently international undertaking. Researchers share the results of their work with a scientific community that spans the planet through a growing array of collaborative efforts, technical journals, conferences, the Internet, and dedicated high-bandwidth data networks for research and education.

This increasingly global scientific enterprise straddles national boundaries to create a set of relationships in which traditions and cultures mix in cooperative ways, despite temporary setbacks arising from security concerns and economic competitiveness.

On the following pages, scientists, engineers, researchers, and educators who work with international colleagues at the leading edge of this global movement to share knowledge describe their work and preview the future of international collaboration.

Scientists at work on a device that is part of the Compact Muon Solenoid Collaboration at CERN, the European Organization for Nuclear Research.

Scott Horowitz of NASA describes how, at the dawn of a new space age, the world's spacefaring nations are collaborating to enable achievements in space exploration that are beyond the financial and technical capability of any single country. Three researchers supported by the U.S. National Institutes of Health John E. Fogarty International Center for Advanced Study in the Health Sciences work with collaborators in Thailand, Central and Eastern Europe, and Peru to enhance global health. NASA astrophysicist Joseph Davila tells of a rare total solar eclipse and how it brought scientists from Libya, the United States, Switzerland, Italy, France, and Germany together for the first time in Libya's ancient southern desert to study the sun's corona and broadcast the event to the world. Norbert Holtkamp, who will lead the construction of the world's largest fusion experiment, explains how the International Thermonuclear Experimental Reactor could become a clean energy source for a growing world demand.

These and other experts offer their thoughts on *Sharing Science: Global Partnerships.* ■

SHARING SCIENCE: GLOBAL PARTNERSHIPS

U.S. DEPARTMENT OF STATE / OCTOBER 2006 / VOLUME 11 / NUMBER 3

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Science and Technology: A Bridge Between Cultures and Nations

George Atkinson, PhD, Science and Technology Adviser to the Secretary of State, U.S. Department of State

George Atkinson came to the U.S. Department of State in August 1981 as a Senior Fellow for Science, Technology, and Diplomacy, sponsored by the American Institute of Physics. In 2003, then-Secretary of State Colin Powell named him to become the second Science and Technology Adviser to the Secretary of State. He remains a professor of chemistry and optical sciences at the University of Arizona (on leave).

Science and technology advances have immediate and enormous influence on global and national economies and international relations, and nations are largely shaped by their expertise in and access to science and technology. Those who create technology have a different set of options for the future than those who must purchase their technology. Scientific research increasingly defines material futures by identifying many potential technological opportunities and the challenges to social and governmental institutions in converting those opportunities into real-life advantages.

The scientific advances of our time are different than those of the 20th century because they have an immediate and often enormous influence on the global economy and therefore a direct influence on international relations. Many, if not most, nations have lifestyles, economies, and societal structures largely influenced by their expertise in science and technology and secondarily by their access to science and technology.


©AP/Images Joerg Sarbach

An international aeronautics fair in Bremen, Germany. Successful innovation depends increasingly on global science and technology cooperation.

Many of the major science and technology advances of our time also offer remarkable new opportunities and challenges to our social institutions and ethical principles. In an increasingly global world, accurate scientific information must inform foreign policy and foreign policy must promote justified science goals. Since these opportunities have global impact, successful innovation will increasingly depend on global science and technology cooperation.


Courtesy of the State Department

George Atkinson

The international role of science and technology is continuously changing. Throughout most of the 19th century and at the outset of the 20th, Europe was the dominant power in scientific research and technology development. Beginning in the mid-20th century and at the outset of the 21st century, the United States has evolved into the dominant global power in scientific research and technology development.

History teaches us that leadership in science and technology is transitory. The fundamentally collaborative nature of science, coupled with the trend toward international partnerships, will ensure that science leadership is much more evenly distributed among nations in the future.

Why are science and technology so important in worldwide conversation today beyond their economic importance? Because they also involve cultural changes, and we as nations have not always paid enough attention to them. The fundamental concepts that most scientists and engineers extract from their education are the same that foster and sustain democratic societies—the meritocracy of ideas that transcend borders and cultures; transparency, in the form of publication of results; and the importance of public education, which begins any discussion concerning innovation.

Science-based decision making is the way of the future. We are likely to have few choices. We cannot legislate changes in the weather, in engineering principles, or in infectious diseases. So we must be able to assure ourselves and publicly reassure our constituents that we have started with information that is well justified, and be willing to share that information without regard to national borders.

The science and technology enterprise must come with the assurance of political and economic stability because innovation can operate only when long-term goals can be realized. If we remember that science is best done collaboratively, we will have a much better vision of how to improve it. In the global science and technology enterprise of the future, it will be best if we all succeed together. ■

Nations in Space

Scott Horowitz, PhD

©AP Images/NASA

International Space Station and space shuttle *Discovery* crew in the station's *Destiny* laboratory. Led by the United States, the space station program draws on the scientific and technological resources of 16 nations—Brazil, Canada, 11 nations of the European Space Agency, Japan, Russia, and the United States.

Courtesy of NASA

Scott Horowitz

Space exploration began when people on Earth looked to the heavens and began documenting the motions of stars and planets. Today, 12 men have walked on the moon, and more than 80 countries have worked together to send robotic spacecraft to nearly all planets of our solar system. At the dawn of a new space age, the world's spacefarers are collaborating to enable achievements that are beyond the financial or technical capability of any one nation.

*Scott Horowitz, PhD, is the associate administrator for the Exploration Systems Mission Directorate (*http://exploration.nasa.gov*) at NASA Headquarters in Washington, D.C. A retired U.S. Air Force colonel, Horowitz flew on four space shuttle missions and worked as NASA's acting deputy associate administrator for safety and mission assurance.*

Over the past 50 years, humans have made significant strides in space exploration. What rises above the specific details of these accomplishments, however, is the worldwide effort and cooperation that made them possible. I believe that the growing spirit of collaboration, linked to the growing number of nations and organizations involved in space and the increasing scope of global space activity, will provide the framework required for even greater accomplishments.

The number of countries involved in space exploration has grown from a small, select group beginning in the 1950s to more than 80 nations that today have organized efforts to use space exploration to benefit their societies. The future of space exploration will be grounded in such international involvement and, more importantly, in collaboration among nations to benefit people everywhere.

The history of space exploration is rich. In 1609, people began to explore the heavens visually thanks to improvements that Italian astronomer Galileo Galilei made to the telescope. Credited as the first to use the telescope for astronomical purposes, Galileo made it possible to observe mountains and craters on the moon's surface.

In such beginnings, the dream of lunar and planetary exploration was born. Now, 12 men have walked on the moon, and a wide range of unmanned missions to the moon and several planets have been completed. In just the past 10 years, 150 planets have been discovered beyond our solar system. Closer to home, world citizens have reaped enormous benefits from space exploration through satellites that support communication, navigation, weather observation, and other remote-sensing disciplines. Space-related technologies and scientific knowledge have contributed to high-performance computing and robotics, scratch-resistant eyeglass lenses, breast cancer imaging, and much more.

For the near future, even more ambitious space exploration plans are in development. With completion of the New Horizons mission, the first spacecraft to visit the dwarf planet Pluto and its moon Charon in 2016-2017, the world's spacefaring nations will have sent robotic spacecraft to all the planets of our solar system. No later than 2020, we expect humans to once again walk on the moon. As the magnitude of space exploration increases, so does international, collaborative effort.

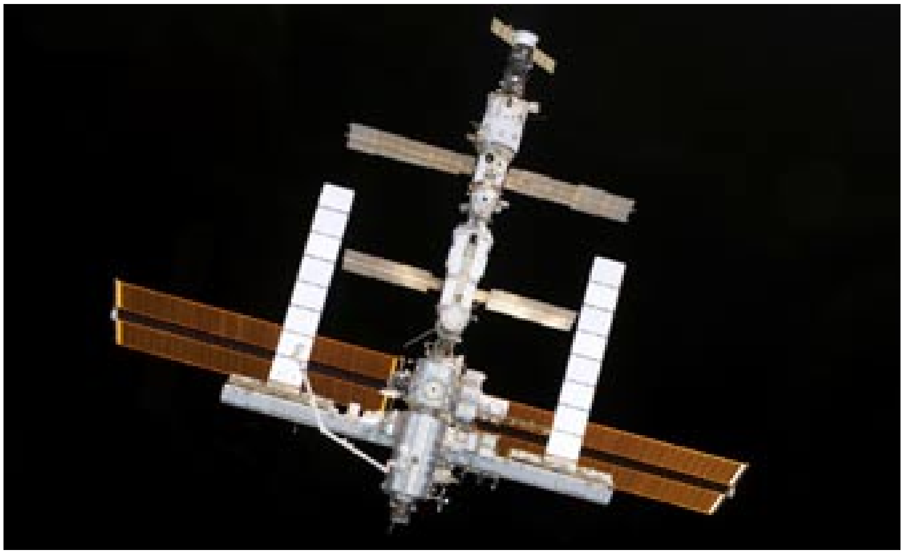
A good example of early space cooperation is the study of Halley's comet during its approach to the sun in 1986. Five years earlier, in 1981, the space agencies of the Soviet Union, Japan, Europe, and the United States formed the Inter-Agency Consultative Group (IACG) to informally coordinate matters related to the space missions being planned to observe the comet. In 1986, five spacecraft from these nations rendezvoused with Halley's comet. The vital information exchanged as a result of IACG collaboration was invaluable in studying the comet.

©AP Images

Astronaut Donald Slayton, cosmonaut Aleksey Leonov, and astronaut Thomas Stafford (left to right) in the Soviet Soyuz Orbital Module during the joint U.S.-USSR Apollo-Soyuz Test Project in July 1975.

In human spaceflight, international collaboration has grown from the seeds of early programs such as *Skylab,* the Apollo-Soyuz Test Project, and the Space Shuttle-*Mir* Joint Program, to the current International Space Station effort, one of the most incredible engineering accomplishments in history.

The Apollo-Soyuz Test Project, July 15-24, 1975, was the first international manned space flight. The mission


©AP Images/NASA
The International Space Station against the blackness of space as the orbital outpost moves away from the space shuttle *Discovery* on August 6, 2005.

was designed to test rendezvous and docking systems compatibility for American and Soviet spacecraft and open the way for international space rescue and future joint manned flights.

The Space Shuttle-*Mir* Joint Program, February 1994 to June 1998, went well beyond the scope of earlier collaborative programs, encompassing 11 space shuttle flights and seven U.S. astronaut residencies, called increments, on the Russian space station *Mir*. Space shuttles also conducted crew exchanges and delivered supplies and equipment. Shuttle-*Mir* showed that space exploration no longer had to be defined as a competition between nations and helped Americans and Russians develop the expertise to build and maintain the International Space Station.


©AP Images/NASA TV
A television image of International Space Station crew members (front to back) astronaut Jeff Williams, European Space Agency astronaut Thomas Reiter, and cosmonaut Pavel Vinogradov before a scheduled space walk on September 12, 2006.

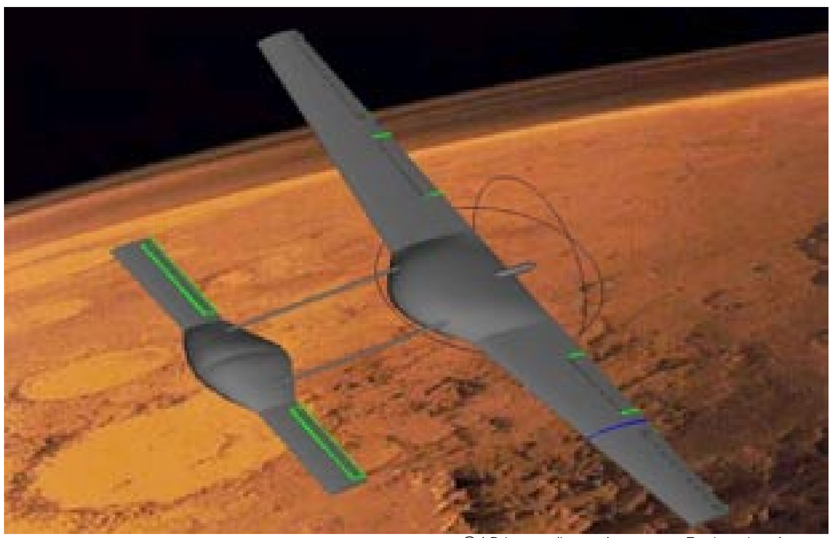
The International Space Station is the largest international science collaboration in space today. The United States, Japan, Canada, Russia, and 11 countries represented by the European Space Agency have come together to build and inhabit the station. Through the science performed there, these nations seek to improve life on Earth and pave the way for future space exploration. The space station partnership has illustrated its strength and commitment with its perseverance through various strains, including aftershocks from the loss of the U.S. space shuttle *Columbia* in 2003.

Such cooperative endeavors serve as inspiration for the future. When great nations seek great endeavors, they find more success with allies and partners. Space exploration is the great endeavor of our time.

As much as we can take pride in our past accomplishments, the dawn of a new space age lies ahead. In a relatively short amount of time, I believe the people of Earth will look through their telescopes at the moon to see evidence of human and robotic exploration activity benefiting people everywhere.

They may see a surface research station, manned by an international crew that is working to obtain useful resources from the lunar regolith—a layer of loose rock resting on bedrock—as part of an effort to enable crews to live more independently of Earth. Antennas may be deployed on the far side of the moon that can be linked in phase to form the largest radio telescope ever built, free from the interference of radio noise from Earth. Other astronauts may be geological explorers, looking for clues to the origins of the Earth-moon system and life itself. While these activities are taking place, still others may be readying a 500-ton spaceship for humankind's first voyage to Mars.

Already, many nations have initiated lunar exploration efforts. The European Space Agency's Small Mission for Advanced Research in Technology orbited the moon in 2004. Over the next several years, other spacecraft will follow, including the Selenological and Engineering Explorer from Japan, *Chandrayan* from India, *Chang'e* from China, and the Lunar Reconnaissance Orbiter and its secondary payload, the Lunar Crater Observation and Sensing Satellite, from the United States. Each mission has some degree of international collaboration.



An artist's rendering from the Japan Aerospace Exploration Agency of a spacecraft flying above the surface of Mars.

In 2006, the world's spacefaring nations began discussing how they will work together to advance scientific, economic, and exploration progress on the moon. This effort begins now, with the planning and implementation of precursor robotic missions. These interactions are the seeds of future collaborative efforts.

NASA is compiling input from various communities, including international space agencies, to generate a global strategy of lunar exploration objectives. NASA presented this strategy at its Next Generation Exploration Conference, a gathering of emerging global space leaders, in August 2006.

As spacefaring nations come together to develop a vision of common and unique interests in the moon, we lay the groundwork for a momentous leap forward in space exploration. Some among us may see the moon as an end in itself, a unique location from which to investigate the processes that formed our solar system and a nearby location where self-sufficient human settlements may lay the groundwork for people to live and work on other worlds. Others may see the moon as a test site for technologies and operational techniques that will someday apply to the human exploration of Mars and other destinations. Still others may view the moon as an incredible resource that may help us solve energy and other problems here on Earth. Lunar exploration that is sustainable over the long term will require the efforts of all of us, with our many views of the role of the moon in human exploration and development.

When I was an astronaut, I experienced firsthand the benefits of international cooperation in space exploration. I believe in the great value of space exploration for people throughout the world. Although humankind's first steps onto another world were taken by a dozen early explorers from America, it will take all of our nations, working together, to accomplish the great endeavor of space exploration that lies before us and to enable future generations of explorers to do the things we can only imagine today. ■

In Education City

Charles Thorpe, PhD

Courtesy of Carnegie Mellon University-Qatar

At the Doha, Qatar, campus of Pennsylvania's Carnegie Mellon University, 50 students representing many nationalities are in the 2006 incoming class.

In 2004, Carnegie Mellon University, a private research university based in Pittsburgh, Pennsylvania, opened its first international branch campus (http://www.qatar.cmu.edu) *in Doha, Qatar, offering students in the Persian Gulf undergraduate programs in computer science and business administration. At the invitation of the Qatar Foundation for Education, Science, and Community Development, Carnegie Mellon has joined several other U.S. universities in Education City, an effort to make Qatar a world-class center for education and research.*

Courtesy of Carnegie Mellon University-Qatar

Charles Thorpe

Charles E. Thorpe, PhD, is dean of Carnegie Mellon University-Qatar and a faculty member and former director of the Carnegie Mellon Robotics Institute in Pittsburgh, where he led a research group that developed unmanned research vehicles. Thorpe, also a faculty member at Carnegie Mellon-Qatar, teaches Introduction to Mobile Robotics.

Carnegie Mellon University has international programs in Australia, the Republic of Korea, Japan, and Greece, and we do collaborative work all over the globe. At our Pittsburgh campus, a quarter of our undergraduate student body is international. But Carnegie Mellon-Qatar in Doha is our first full undergraduate program overseas. Qatar is ideal because it has the vision and resources to foster education at a high international standard. At Carnegie Mellon-Qatar, 40 students just finished their sophomore year, 50 just finished their freshman year, and about 50 students are in the 2006 incoming class. Eventually, we will admit up to 100 students per year when we have our own building in 2008.

The Qatar Foundation asked us to do everything in Doha that we do in Pittsburgh, which means we teach classes in English and they are fully coed (men and women attend the same classes). We teach a U.S. curriculum according to U.S. standards, and 73 percent of the new freshman class is female. We're also there to do research and consulting and to engage society. Having friendly Americans in an unusual part of the world builds bridges in both directions. We learn how friendly our Qatari colleagues are, and they learn the kinds of expertise we can bring and that Americans have a wide range of political opinions. It turns out to be a very healthy exchange.

Being in Qatar benefits Carnegie Mellon in many ways. We're learning about the students, the research opportunities, and how to work with people in the Gulf Region. We're also making the Carnegie Mellon name visible in an important part of the world and broadening our student body base—the 90 students we've had so far represent 18 nationalities.

Faculty and undergraduate students from Pittsburgh live, work, and learn in Doha, and five students from Doha lived and studied in Pittsburgh for the first half of the summer of 2006. That mixing of the Pittsburgh and Doha bases strengthens people on both sides.

One of the most interesting classes we ran in 2005 was called U.S.-Arab Encounters. Students in Pittsburgh and Doha would read about U.S.-Arab relations, then twice a week we would fire up the big-screen videoconference unit and the students would have discussions. It was fascinating to hear the preconceptions and misconceptions about what was happening on either side. There were some very vigorous exchanges of opinion, and the course got outstanding ratings from students, faculty, and visitors.

We have a rapidly growing science presence, but it began slowly. The first year, most of the Doha faculty had a teaching agenda, not a research agenda. As we grow, especially now that we're getting into junior- and senior-level classes, I'm bringing over more research-oriented faculty.

An example of applied research that will have a short-term impact in Qatar involves diabetes and health care. Qatar has the third-highest incidence of diabetes in the world, and the question is, why? Some of it has to do with small gene pools, some with diet and exercise habits in that

Courtesy of Carnegie Mellon University-Qatar

Carnegie Mellon-Qatar experts helped local high school students who participated in the Second International Botball Robotics Challenge in Doha.

part of the world. Before going to Doha, I was director of the Robotics Institute at Carnegie Mellon in Pittsburgh, and one of my PhD students from the institute is now in Qatar to investigate using intelligent computer-based methods to monitor diabetics and help them control their own medication, diet, and exercise regimes.

Another of my PhD students is in Qatar doing core robotics work with a mobile robot that builds high-resolution maps of the city. Everything in Qatar is under construction all the time, so if you can run around and update maps rapidly, that is very useful.

We teach two robotics courses as part of the computer science curriculum, so all the computer science students and most of the business students take at least one of those courses. It's fun because the students are learning robotics, but they're also learning computer programming. We divide them into teams and they work together doing public presentations on the robots they've built, so they're also learning presentation skills.

On the campus of Education City, the Qatar Foundation started putting together a "multiversity" rather than a university. Carnegie Mellon-Qatar is there to teach business and computer science. Georgetown University (Washington, D.C.) is there teaching foreign policy, Cornell University (Ithaca, New York) is establishing a pre-med program and a medical school, Texas A&M University (College Station, Texas) is teaching engineering, and Virginia Commonwealth University (Richmond, Virginia) is teaching design. We're all in walking distance of each other, and we've started cross-registering courses. We also do joint programs with Qatar University, a few kilometers away. It's a very interesting mix of courses that you can't find in any single campus setting anywhere else in the world. ■

The opinions expressed in this article do not necessarily reflect the views or policies of the U.S. government.

Curing Disparity

Donald Burke, MD; Thomas Cook, PhD; Patricia Garcia, MD, MPH

Courtesy of Thomas Cook, PhD

Trainees from eight countries in Central and Eastern Europe who are involved in a University of Iowa project funded by the Fogarty International Training and Research Program in Environmental and Occupational Health gather at a meeting in Slovakia.

To eliminate health disparities worldwide, the U.S. National Institutes of Health John E. Fogarty International Center for Advanced Study in the Health Sciences fosters partnerships between U.S. scientists and foreign counterparts through grants, fellowships, exchange awards, and international agreements that support a range of activities. The stories that follow—about teaching epidemiologists in Thailand how to develop and run computer models of infectious diseases, helping developing democracies in Central and Eastern Europe build capacity in environmental and occupational health, and enhancing the contribution and participation of researchers in Peru to the global health agenda—are told by Fogarty-funded researchers who share their knowledge worldwide.

Curing Disparity: Epidemiology in Silicon

DONALD BURKE, MD

Dean and Jonas Salk Chair of Global Health in the Graduate School of Public Health at the University of Pittsburgh

Courtesy of Donald Burke, MD

Donald Burke

For two years I have been principal investigator on a grant from the U.S. National Institutes of Health to develop computer models of infectious disease epidemics that may be important to national security. My group decided influenza was a top priority, so we did two types of influenza modeling. For one part of the modeling effort, we worked with collaborators in Thailand to develop simulations of a hypothetical epidemic in Southeast Asia. Then we used the model to determine if intervention strategies could stop an early-stage epidemic in its tracks—what we call "quenching" an epidemic—in Asia before it spread worldwide.

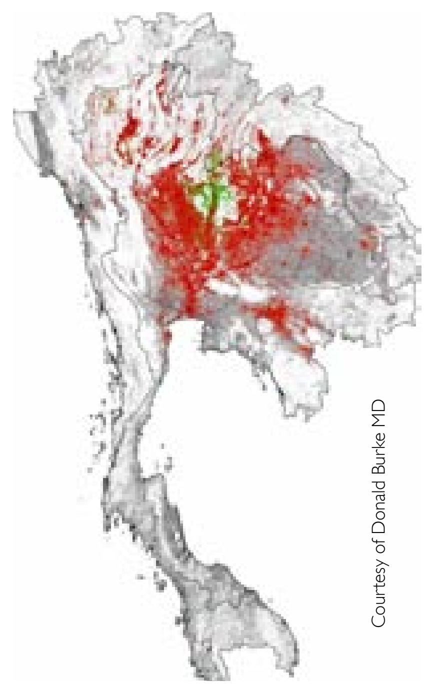
To do that, we created a simulated population for Southeast Asia, focusing on Thailand. Our simulation distributed 85 million individuals onto a map according to population densities. We put them in households, schools, and workplaces—basically creating an artificial society in the computer. We computationally released an influenza virus into the population and studied the transmission patterns that ensued. Then we evaluated what would happen if Thailand treated cases, treated families, closed the schools, or geographically restricted people's movements. We are testing policies—plans, procedures, and actions designed to bring about a desired governmental goal, in this case epidemic control—in the simulation, and we call it "epidemiology in silicon."

It isn't possible to rigorously test policies before an epidemic explodes, but by doing it with a simulation that has some fidelity to natural patterns, you can ask if certain combinations of policies are likely to be more effective under certain circumstances. We published our findings in *Nature* magazine (September 7, 2005). The main conclusion was that if you responded to a nascent epidemic at a reasonably early stage—fewer than 50 cases—and used an aggressive strategy of treating the cases and everyone in the geographic area with antiviral drugs, it would be possible to contain or quench the outbreak before it became an epidemic.

The second part of our modeling effort, published in *Nature* on July 26, 2006, was to do the same thing for the United States—create a simulation of population density, movement patterns, households, workplaces, schools, distributed airline travel, and local travel. The difference in the United States is that we don't expect to be able to completely stop an epidemic. At the height of a global pandemic, such a high percentage of potential travelers would be incubating or ill with influenza that stopping even 99 percent of air travel into the United States would still allow a large number of infected persons into the country by airplane.

These computer models are computationally intensive. We run the models thousands of times because every time we run them, just as chance influences reality, we get somewhat different results. To assess a policy, we have to run a simulation multiple times to see, on average, what effect an intervention-strategy policy option will have on the epidemic. Depending on the simulation, each run can take half an hour on a supercomputer.

In mid-2005, we were just finishing the Southeast Asia quenching modeling work when an opportunity came through the Fogarty International Center to



Courtesy of Donald Burke MD

Computer simulation of an outbreak of transmissible avian flu in Thailand. Red indicates new cases; green indicates areas where the epidemic has ended.

increase Thai involvement. The Thais were very expert from the policy side, but they didn't have modeling sophistication because most epidemiologists in Thailand don't have a background in computational modeling and simulation. With Fogarty's support, we worked with the Thai epidemiology training program through the Ministry of Health and provided training opportunities in modeling. The key collaborator there is Dr. Kumnuan Ungchusak, director of the Bureau of Epidemiology in the Department of Disease Control at the Ministry of Public Health.

Our group is working with the Thais on three levels. First, we worked directly with them as research colleagues to develop models. They were wonderfully helpful in this—we could not have completed our first modeling effort without our Thai colleagues. Second, we have worked on more classroom-oriented types of interactions, where larger groups learn the technology but are also exposed to computational approaches to modeling epidemiology. In June 2006, the Thai students completed a course for field epidemiologists. In addition to a regular epidemiology course, my junior colleague, Dr. Derek Cummings, gave a series of classes on modeling opportunities for 25 or 30 students in the class. Third, which isn't yet accomplished because we're still early in the program, we will identify degree candidates to work on projects that are in part related to modeling and simulation.

Curing Disparity: Environmental and Occupational Health for Developing Democracies

THOMAS COOK, PHD

Professor of Occupational and Environmental Health at the Center for International Rural and Environmental Health in the College of Public Health at the University of Iowa

Courtesy of Thomas Cook, PhD

Thomas Cook

At the University of Iowa, we began working with health professionals from Central and Eastern Europe in 1996 to help these low- and middle-income countries build their capacity to improve occupational and environmental health. Today, professionals from Hungary, Poland, Slovakia, and Romania work with us as part of the Fogarty International Training and Research Program in Environmental and Occupational Health, and program activities have included health professionals from as many as 13 countries throughout the region.

Environmental health issues can include water quality and the health effects of poor water quality, air and industrial pollution, and soil pollution by fertilizers, pesticides, heavy metals, and other contaminants. Occupational health issues include injuries and trauma in the workplace, industrial and agricultural injuries, and work-related chemical exposures.

There's a close link between occupational and environmental health issues, particularly in rural areas. Our focus at the University of Iowa is rural health. In the 1950s, we had one of the first centers for agricultural medicine in the United States, so we're very interested in rural health issues and have a fair amount of experience and expertise in issues like pesticide poisonings and water contamination in rural areas.

Some people believe living in the countryside is healthy and wonderful, but the data worldwide tell you differently—a large number of serious health issues are related to rural and remote populations. These include the lack of preventive health and emergency services for people who live long distances from medical facilities, and water contamination by pesticides and fertilizers. In several Central/Eastern European countries, as many as 80 percent of the rural villages have water supplies with chemical or biological contamination.

We help people in Central/Eastern Europe deal with environmental and occupational problems by training physicians and public health professionals in a wide range of specialties—people who know how to test well water, how to recognize health problems, and how to collect data so policies and regulations and laws can be changed. We've trained nurses, engineers, physicians, epidemiologists, and public health media specialists.

Courtesy of Thomas Cook, PhD

A Fogarty International Center/University of Iowa occupational health trainee conducts a survey related to well-water safety in Romania.

In each country, we identify at least one institution that is responsible for rural and environmental health and work with them to select and train the people they need. For example, the Nofer Institute for Occupational Medicine in Lodz, Poland, is that country's leading occupational health institution. We will soon welcome the seventh health professional from that institution to our training program on the University of Iowa campus. The model we use is what Fogarty International Center calls intermediate-term training, meaning the students come to the University of Iowa for a 15-week semester. We and our collaborators jointly identify a student, who travels to the United States and takes graduate-level courses in the College of Public Health or a related college. The student is also matched with a faculty mentor who has expertise in the student's field.

While they are at the University of Iowa, students formulate a small research project that will be funded and that they will work on when they return home. Within a year after they return home, their faculty mentor travels to the country and together they present a continuing education program for the student's colleagues and other professionals from the region. It gives the trainees recognition as experts, and they are able to share what they have learned. We think it's a great program.

It takes a few years for the training to pay off—to get a critical mass of experts in each country. In northwestern Romania, for example, the country's third largest city, Cluj-Napoca (population 350,000), is in a very rural area. To date, we've had five trainees from Cluj, young, energetic physicians who are working hard to expand the scope and impact of public health in their country. We've found resources to fly experts there to conduct seminars and workshops, and we've significantly expanded our use of Internet-based education programs to help in capacity-building efforts throughout the region.

Curing Disparity: Global Health Peru

Patricia Garcia, MD, MPH

Principal Professor in the School of Public Health at the Universidad Peruana Cayetano Heredia in Peru and Chief of the Peruvian National Institute of Health

Courtesy of Patricia Garcia, MD

Patricia Garcia

At my university we are working to develop a global health framework and train a new generation of health scholars and investigators, doing so with the support of the Global Health Initiative of Fogarty International Center.

My colleagues—Dr. Eduardo Gotuzzo, Dr. Hector Garcia, and Dr. Bob Gillmann—and I at Cayetano Heredia are designing a multidisciplinary program related to global health and infectious diseases that includes people from the schools of medicine, public health, science (biology, chemistry, and mathematics), and mental health. We are also involving colleagues from other fields who have much to contribute to the study of the broad social and economic issues that relate to health. Specialists in social science, education, veterinary science, and dentistry are involved in our program, as are economists, sociologists, lawyers, and health communicators.

We aim to offer a master's degree in global health for our undergraduate students, and we invite people from other countries to come and learn about public health issues in global health in the particular environment that surrounds our institution.

Courtesy of Universidad Peruana Cayetano Heredia

Students participate in fieldwork for a Basic Concepts in Global Health course at the Universidad Peruana Cayetano Heredia in Peru.

Our Global Health Demonstration Program here in Peru was the only program outside the United States that Fogarty fully funded for three years.

In training a new generation of health scholars at Cayetano Heredia University, we want to strengthen the translation of research into health policies and practices, and enhance the contribution and participation of developing-country researchers to the global health agenda. We basically propose to develop a multidisciplinary global health curriculum for undergraduate and graduate students and create a master's degree in global health, initially with emphasis on infectious diseases but also on other areas we consider important, such as chronic diseases.

We also want to design and implement distance-learning programs, expand international faculty exchanges, and develop global health expertise at our university that is not currently available in Peru.

We have almost finished the first year of the program. The idea was to develop an administrative system that would allow different schools within our university to work together—which is usually very complicated in one institution—and have curricula that allow students from different schools to take courses together to promote multidisciplinary approaches.

This year we also launched our Web page (*http://www.globalhealthperu.org)* and two pilot courses—Foundations in Global Health and Basic Concepts in Global Health. In July 2006, we finished Basic Concepts in Global Health, a weeklong course for undergraduate students that includes the participation of different professionals. It's a broad approach to global health that covers economic aspects, social aspects, different diseases of global importance, and fieldwork. We go up to the Andes Mountains for a day so students can put together issues of health and the environment. Next year we plan to extend the course to two weeks and open it to international students.

Another project completed in our first year was an international conference, the First International Conference on Health Problems With Global Impact and Relevance, held in August 2006 in Lima, Peru, for health sciences students and professionals.

For our second year, which started in September 2006, our goal is to organize our master's degree in global health and promote research in global health as part of the program. That will also be part of the third year. Both years will have international students—the interaction between international students and national students is key for the issue of global health.

The Taiwan government provided funding to launch the Peruvian health portal (*http://portal.globalhealthperu.org)*. It is for people who are interested in coming to Peru or learning about diseases located geographically in Peru. Right now we describe only infectious diseases, but our idea is to eventually include mental disorders and other issues. We have health recommendations for travelers and are creating a database of studies of different diseases in Peru by Peruvian researchers.

The course on Foundations in Global Health is an open course for graduate students and has about 80 students. The idea of this course is to evaluate interest in these topics and create a forum for discussion of global health issues. At the end of the course, the students will present monographs on global health issues, and we will publish the best papers in a book that will be out in January 2007.

It's a great opportunity that we are able to promote the development of global health, interaction between researchers from other nations and Peruvian researchers, and the interests of undergraduate and graduate students in global health.

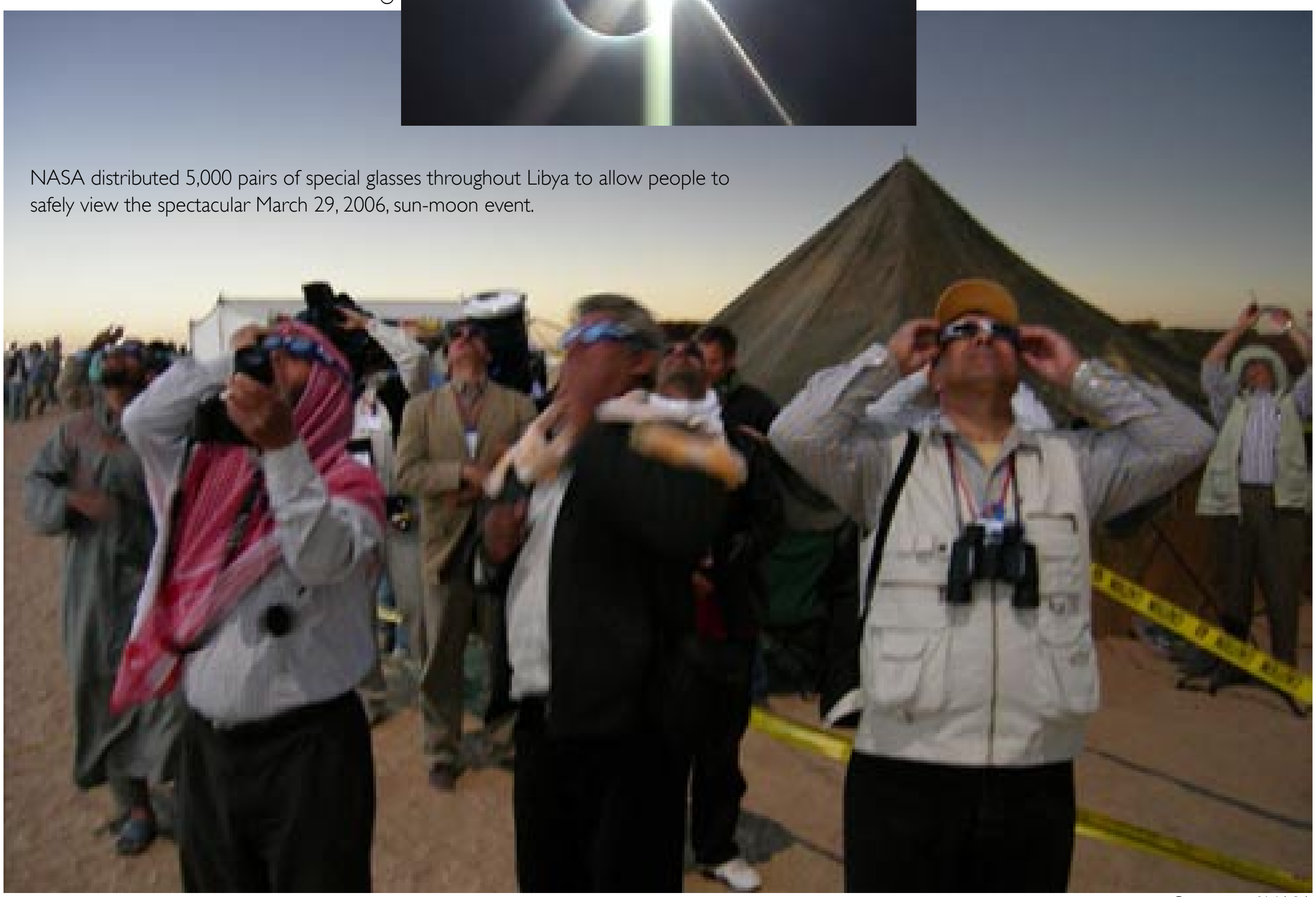
I would like to invite students from other countries who are interested in the program to visit our Web site and learn about how to participate in these courses and, eventually, in the research that will be done through this program. ■

Total Eclipse Cooperation

Joseph Davila, PhD

Courtesy of Nat Gopalswamy, PhD

Near the beginning and end of a total solar eclipse, the sun's edge seems broken into beads of light, called Baily's beads after British astronomer Francis Baily's 1836 discovery. The beads occur because the moon's edge is jagged with mountain peaks. When one bead is visible, the effect resembles a diamond ring. This effect was captured after totality, from Anatolia in southern Turkey.



NASA distributed 5,000 pairs of special glasses throughout Libya to allow people to safely view the spectacular March 29, 2006, sun-moon event.

Courtesy of NASA

Courtesy of Joseph Davila, PhD

Joseph Davila

Joseph Davila, PhD, is an astrophysicist in the Heliophysics Division at NASA's Goddard Space Flight Center in Maryland. His research interests include wave/particle interactions on the sun, the three-dimensional structure of the sun's corona, and the sun's magnetic field.

In March 2006, during a rare four-minute total solar eclipse, astrophysicists from NASA and scientists from research institutions in Libya collaborated for the first time in this North African country on joint scientific activities. Traveling to Libya's ancient southern desert in search of the best eclipse visibility, the scientists studied the sun's corona and helped broadcast the event to people around the world.

Total solar eclipses happen about once a year, on average, somewhere on Earth. On March 29, the four-minute, six-second total solar eclipse occurred when, from Earth's perspective, the moon passed in front of the sun and seemed to be about the same size as the sun. Over the past 50 years, scientists have learned a lot about the sun's corona—where its energy comes from and how it attaches to the rest of the interplanetary medium—but many details are still mysterious.

What many people don't realize is that the sun doesn't end at the yellow ball. The atmosphere of the sun extends all the way through the solar system. Earth travels through the sun's atmosphere, which ends at a region called the heliopause boundary—the outer limits of the sun's magnetic field and outward flow of the solar wind—between 18 billion and 22 billion kilometers from the sun.

The next total eclipse, on August 1, 2008, will be seen in northern Canada, Greenland, Siberia, Mongolia, and northern China. It will last about two minutes. One of the longest eclipses on record will take place July 22, 2009, when totality will last for more than six minutes as seen from a spot in the Pacific Ocean.

Predicting eclipses is easier than predicting space weather, which is similar to Earth weather but originates on the sun. Activity on the sun's surface, like solar flares, can cause high levels of radiation in space that can appear as plasma (particles) or electromagnetic radiation (light). On Earth, space weather can interfere with shortwave radio transmission and electric power grids. In space, space weather can cause satellite orbits to decay and can be a radiation hazard for satellites and astronauts during some phases of space missions.

In studying the sun and the corona, we'd like to develop our science to be comparable with today's weather observations and forecasts, so when people or robots go into space, we can predict what the weather will be. To do that takes a lot more information than we currently have. Right now, we have broad sketches of how things work, so it's not mysterious from that point of view. But in terms of making actual predictions about what's going to happen in space tomorrow, we're not very good at that yet.

The eclipse is special for us because it gives us a chance on Earth to test instruments in conditions that are similar to space. It's much cheaper for us to go to an eclipse observation site and test these instruments than it is to build a spacecraft and test them in space. You're talking about hundreds of millions of dollars in space and tens of thousands of dollars for one of these trips. Neither one is cheap, but this is much cheaper than going to space with a brand new instrument.

Courtesy of NASA

In Libya's Al-Fateh University, where 7,000 students study nearly every engineering and science discipline, NASA's Joseph Davila (left) presents Dr. Hadi A.A. Omar, dean of the faculty of science, with a book about the history of NASA spaceflight for the university library.

After Portuguese explorer Ferdinand Magellan first sailed around the world, the world got smaller and people suddenly needed a science of oceans, ocean currents, jet streams, large-scale winds, and trade winds. People needed to know about the large-scale features in Earth's atmosphere because they were traveling through that atmosphere. It's similar in space. We've just kind of stuck our toe into space, but maybe in the next 50 to 100 years, people will be traveling in space, so we're going to need to know more about the space environment.

To demonstrate new techniques for observing the sun's atmosphere and prototype instruments for future space missions, we and our Libyan collaborators performed two experiments during the eclipse.

In one experiment, we set up a small telescope with a camera that uses filters to capture light from the sun's corona and separate it into different colors of the spectrum. Another experiment—called MACS, for multi-aperture coronal spectrometer—uses a spectrograph to separate the light into individual colors. The filter approach is simpler to implement, but the spectrograph is more accurate. We will compare the two techniques when the data gathering is complete. Much analysis is needed before results can be released to the scientific community, but the results so far are very promising.

By doing these experiments, we're able to measure properties of the electrons that are scattering the light—the density, the temperature, and the flow speed of electrons in the corona. That's information we need to improve computer models of the solar system.

The day after the eclipse, I traveled to Sebha University, 800 kilometers south of Tripoli, to discuss scientific participation in programs related to the International Heliophysical Year 2007, an international program to unite the world's science community from all 191 United Nations member states for scientific collaboration to study the Earth, sun, and solar system as one system.

Throughout the Libyan trip, the people's response to us was overall very positive. Young people were very interested in talking to us and were very friendly. Some of the older people were more wary, but everyone knew NASA and everyone wanted something with the NASA logo on it. We gave away all of our pens, buttons, and NASA stickers.

The photos below and on the following pages show various aspects of our visit to Libya. ■

Courtesy of NASA

After giving a presentation on space weather, NASA solar science, and the sun's influence on Earth's environment, the NASA team lunches with Al-Fateh University faculty, university officials, and visitors. Afterward, NASA and faculty scientists discussed potential areas of scientific cooperation.

Courtesy of NASA

The NASA-Libyan science team arrived by helicopter at Eclipse City, at Waw an Namus near the southwest city of Awbari in Libya's southern desert, three days before the eclipse.

Hundreds of kilometers into the Sahara Desert, scientists from universities and research organizations in the United States, Libya, Switzerland, Italy, France, and Germany participated in the International Symposium on Solar Physics and Solar Eclipses. The International Heliophysical Year, the Libyan government, and the Institute of Astronomy of the Swiss Federal Institute of Technology in Zurich sponsored the conference.

Courtesy of NASA

Courtesy of NASA

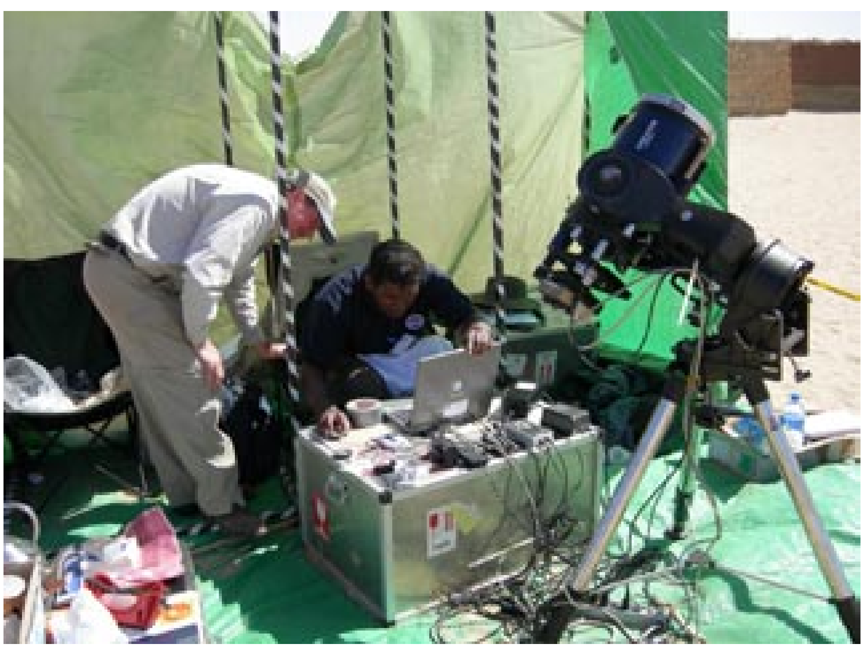
Eclipse City, two years in planning and construction, was a temporary base camp and headquarters provided by the Libyan government. More than 150 scientists and support personnel lived on site. The main tents, dining tents, a community area, and sleeping accommodations are on the right. Tents for soldiers from the Libyan Army, who maintained a security perimeter around the camp, are on the left.

Courtesy of NASA

The temporary tent city had showers, toilets, refrigerated food storage, a gift shop, kitchen and dining tents, and satellite communications. Housing consisted of finely crafted straw huts with carpeting and thick foam mattresses.

Courtesy of NASA

Joseph Davila: "The Libyan government provided telephone service and wireless Internet access, and a communications tent housed equipment that linked us to the rest of the world by satellite. A separate link from Libya Television allowed images from the eclipse site to be transmitted to NASA in the United States and around the world. Libya Television broadcast news from the encampment to the Libyan population."

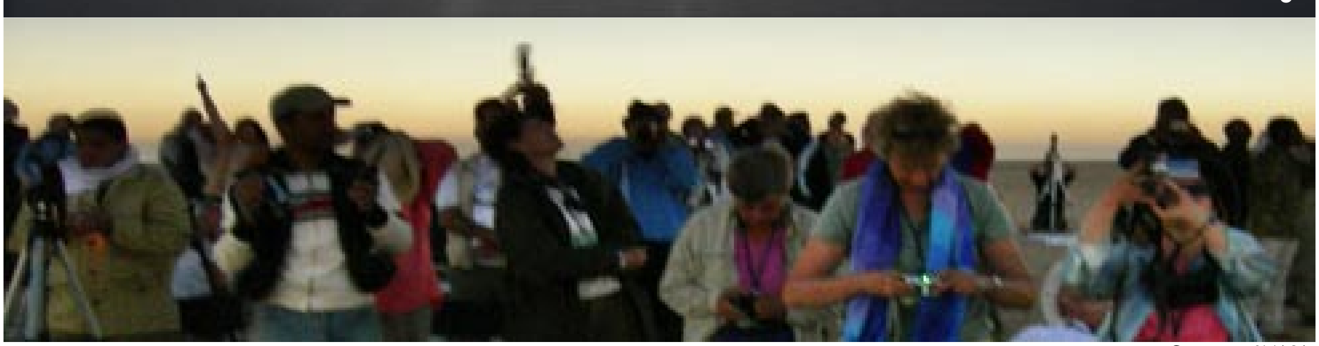


Courtesy of NASA

Orville Chris St. Cyr (left), an astrophysicist in the NASA Solar Physics Branch at Goddard Space Flight Center, and Nelson Reginald, assistant research professor of physics in the Institute for Astrophysical and Computational Sciences at Catholic University of America in Washington, D.C., set up one of two experiments to demonstrate new techniques for observing the sun's atmosphere.

Totality.

Courtesy of Olivier Garde, Grenoble, France



Courtesy of NASA

The U.S. Department of State Office of Science and Technology Cooperation, NASA, and the government of Libya worked in concert to make possible the historic solar eclipse expedition.

Virtual Healing

Gary Selnow, PhD

Courtesy of WiRED

Doctors and medical students in Baghdad access electronic libraries at WiRED International's Medical Information Center at Medical City Center, the largest medical school and teaching hospital in Iraq.

A San Francisco organization is helping Iraqi doctors recover from 20 years of isolation and censorship under Saddam Hussein, using computer technology and the Internet to give Iraq's medical schools quick access to current technical knowledge, electronic research libraries, and video connections with U.S. medical educators.

Courtesy of Gary Selnow, PhD

Gary Selnow

Gary Selnow, PhD, is executive director of WiRED International (http://www.wiredinternational.org) *and a professor with the Marian Wright Edelman Institute at San Francisco State University in California.*

Twenty years of censorship in Iraq effectively isolated Iraqi doctors from advances in medicine. Saddam Hussein blocked e-mail and Internet communication, banned travel to professional conferences, and cut off access to medical journals and textbooks. The result is that Iraqi medicine, once among the best in the world, has become among the least informed anywhere.

This became evident soon after our small group from WiRED International, a nongovernmental organization that pioneered computer-based medical information programs after the Balkan Wars in 1997, entered Iraq on the heels of the coalition forces in 2003. Sponsored by the U.S. State Department, we looked at how we might use information technology to help Iraqi medical schools obtain quick access to current technical information. An American technician and I joined with Iraqi doctors and technicians to install electronic libraries in Baghdad-area teaching hospitals. In a single day, we converted empty rooms into research libraries called Medical Information Centers (MIC).

An MIC is a collection of interconnected computers that draws technical material from two sources. Where satellite connections are available, MICs provide access to the Internet's rich online resources at the world's leading medical schools and research institutes, the World Health Organization, and U.S. government health agencies. These are valuable databases for any user, but in places where medical journals are few and far between, and where textbooks are older than some medical students, the Internet is a brimming source of technical knowledge.

Where the Internet is not available, or unaffordable, WiRED stocks electronic libraries with as many public-access journals, texts, and research papers as we can load onto a computer hard drive. Each MIC is then outfitted with this stand-alone library that can be used without an Internet connection.

WiRED installed the first four MICs in Baghdad in June 2003, and by June 2006 we had set up 39 of these centers at hospitals across Iraq.

We recently augmented the MICs with videoconferencing equipment at medical schools in Baghdad, Basrah, Erbil, and Mosul. These systems provide direct, high-speed audiovisual communications between Iraqi and American physicians for lectures, seminars, and patient assessments. WiRED's consortium partners at Children's National Medical Center in Washington, D.C., the University of California-San Francisco Medical School, and San Francisco State University College of Nursing provide most of the medical content. This is the only program in Iraq providing Iraqi medical educators with direct links to the outside medical community. These electronic telemedicine bridges, along with the MICs, give Iraqi doctors a chance to break the isolation they've suffered for so many years.

Understanding the potential outcomes of this program is why WiRED treasures words like these from Dr. Kahalid N. Mayah of the Basrah Teaching Hospital: "WiRED may be the best thing done for Iraq. Many nonprofits came to Iraq, some stayed, some went, but your effort to make Iraqi doctors enter to the world of scientific research and information systems was the best thing done."

All of us at WiRED are volunteers. We hope that our work in Iraq, as in all the countries we serve, demonstrates the abiding goodwill of the American people. WiRED seeks to unite medical communities around the world through improved communication. We believe that a universal quest for good health can become the tie that joins us together. ■

The opinions expressed in this article do not necessarily reflect the views or policies of the U.S. government.

Courtesy of WiRED International

A satellite links doctors at San Francisco State University in California and the Medical Information Center in Baghdad.

ITER: Fusion Energy Future

An interview with Norbert Holtkamp, PhD, the scientist who, with ITER Director-General Kaname Ikeda, will lead the construction of the world's largest fusion reactor.

©AP Images/Thierry Charlier

Ministers from the European Union (EU), the People's Republic of China, the United States, and the Russian Federation sign the International Thermonuclear Experimental Reactor agreement at the EU Commission Headquarters in Brussels in May 2006.

The International Thermonuclear Experimental Reactor (ITER, http://www.iter.org) *is a joint international research and development project among seven parties worldwide to demonstrate the scientific and technical feasibility of using the power of fusion—which arises from combining the nuclei, or centers, of two atoms—as an energy source for growing world demand. ITER will be built in Cadarache, France, for operation in or near 2016.*

Courtesy of ITER

Norbert Holtkamp

Norbert Holtkamp, PhD, is ITER's principal deputy director-general nominee and project construction leader. He was born in Germany and has held positions at the Deutsches Elektronen Synchroton in Hamburg, Germany, and the Fermi National Accelerator Laboratory in Illinois. Beginning in 2001, he coordinated and led the design and construction of the accelerator of the Spallation Neutron Source (SNS) at the U.S. Department of Energy Oak Ridge National Laboratory. Completed in May 2006, the SNS is a $1.4-billion accelerator-based source of subatomic particles called neutrons that will provide the world's most intense pulsed-neutron beams for scientific research and industrial development.

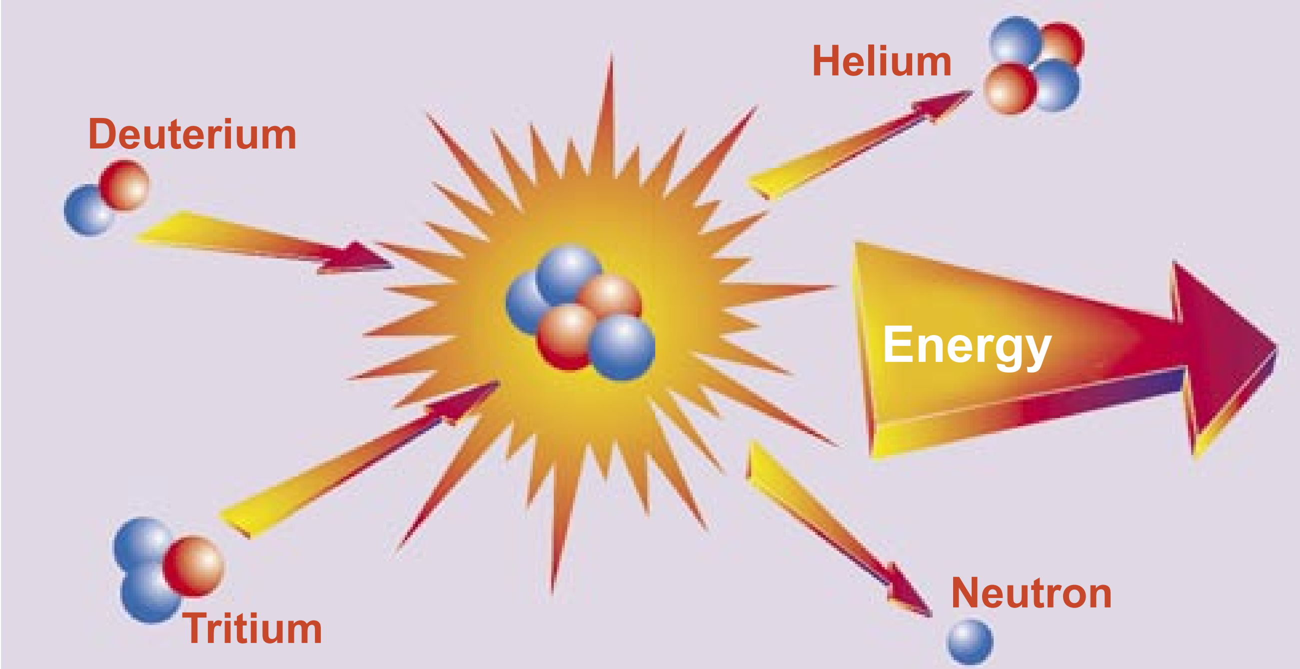
In a world where energy needs are rapidly growing beyond the available supply capacity, scientists from around the world are working to harness the power of the sun and stars and use this resource to meet the planet's rising demands. The European Union, the Republic of Korea, India, China, Japan, Russia, and the United States are forming the ITER Organization to develop this means of energy generation. In this interview, Dr. Norbert Holtkamp, ITER deputy director-general nominee and the scientist who will lead the construction of the world's largest fusion reactor, discusses ITER and the progress of fusion research. Dr. Holtkamp spoke with *Global Issues* science writer Cheryl Pellerin.

Question: What is the ITER project?

Holtkamp: ITER is an abbreviation for International Thermonuclear Experimental Reactor, and it also has a Latin meaning—iter means "the way" in Latin. ITER is the intent to build the largest fusion reactor experiment in the world. A much smaller version of it exists now. JET—the Joint European Torus—the largest nuclear fusion experimental reactor device yet built, began operating in 1983 near Culham, England. ITER is the next step toward constructing fusion power reactors to generate electricity.

Q. What are fission and fusion?

Image Courtesy of ITER



Fusion, Briefly: This article discusses the workings of atoms—the tiny particles that make up all matter. Atoms contain three main "subatomic" particles—protons, neutrons, and electrons. Protons and neutrons are heavier than electrons and exist in the atom's center, called a nucleus. Lightweight electrons exist in a cloud that surrounds the nucleus. Each atom's weight equals its protons plus its neutrons. Hydrogen is the lightest element, with one proton and no neutrons. Its atomic weight is 1. Iron is an example of a heavy element, with 26 protons and 30 neutrons; its atomic weight is 56. Fusion in atoms lighter than those of iron produces energy, and fusion in heavier elements requires energy. The number of protons for a given element never changes, but the number of neutrons can change. Atoms of elements that have the same number of protons but different numbers of neutrons are called isotopes. Hydrogen has three isotopes—protium (one proton, no neutrons), deuterium (one proton, one neutron), and tritium (one proton, two neutrons). At ITER, fusion will be the combination of two of these light atoms, deuterium and tritium, to form a more stable heavy atom, helium, and a neutron, both of which carry kinetic energy. Fusing them will release excess energy.

Holtkamp: *Fission* is getting energy from breaking up heavy atomic nuclei. Fission is a process that is controlled in a nuclear reactor and uncontrolled in a nuclear bomb. *Fusion* is fusing two light nuclei together. In the case of ITER, two hydrogen nuclei are basically melded together. When that happens, energy is freed up and comes out.

Q. Why is fusion better for this project than fission?

Holtkamp: Lots of nuclear fission reactors are operational and used to make energy right now, so fission has the advantage that it works today. Fusion is not something that works yet, it's a research project. Both—fission and fusion—are nuclear processes, but they are fundamentally different. The advantage of fusion is that one waste product from the reaction, helium, is not radioactive, and the other, a neutron, is used to make the hydrogen isotope tritium from lithium-bearing materials surrounding the plasma [ionized gas]. In a fission reactor, when you break up these nuclei, the two pieces that are left over are both radioactive. In a fusion process, that's not true—the chamber that surrounds the nuclei becomes mildly radioactive, but the by-products are not.

The big thing with fusion is that the deuterium and lithium, which is used to make tritium, used in the fusion process are available in vast amounts—they are abundant in the earth and in the sea. That's not true for fission reactors, where you have to use uranium, which is in limited supply, or something like it to operate them. But it's not fair to sell fusion as a better process yet because fusion devices built right now are research experiments, not reactors—scientists are trying to find out how to use fusion to create energy. If ITER is successful, it will be the first fusion reactor device that will create significantly more energy than it uses. That's a major step.

Q. Where did the idea for ITER come from?

Holtkamp: It came from international cooperation in fusion research and was proposed by Soviet President Mikhail Gorbachev in a meeting with French President François Mitterrand and subsequently U.S. President Ronald Reagan at the Geneva Summit in 1985. The three presidents got together and decided to do something about energy resources and see what other energy sources science could make available once we run out of coal and oil. Fusion was always a very international research topic, and at these summits, energy, of course, is a big discussion point. It drives every economy, every state. It wasn't a scientific discussion, but they came together and said this was something we should be doing. We should be putting the world's brain power together, and do it together, and share the results of the research.

U.S. President Ronald Reagan (left) and Soviet leader Mikhail Gorbachev during their November 1985 meeting at the Geneva Summit in Switzerland where they and French President François Mitterrand first agreed to work together to find new energy resources.

Q. What are ITER's scientific and technical objectives, and what will it demonstrate?

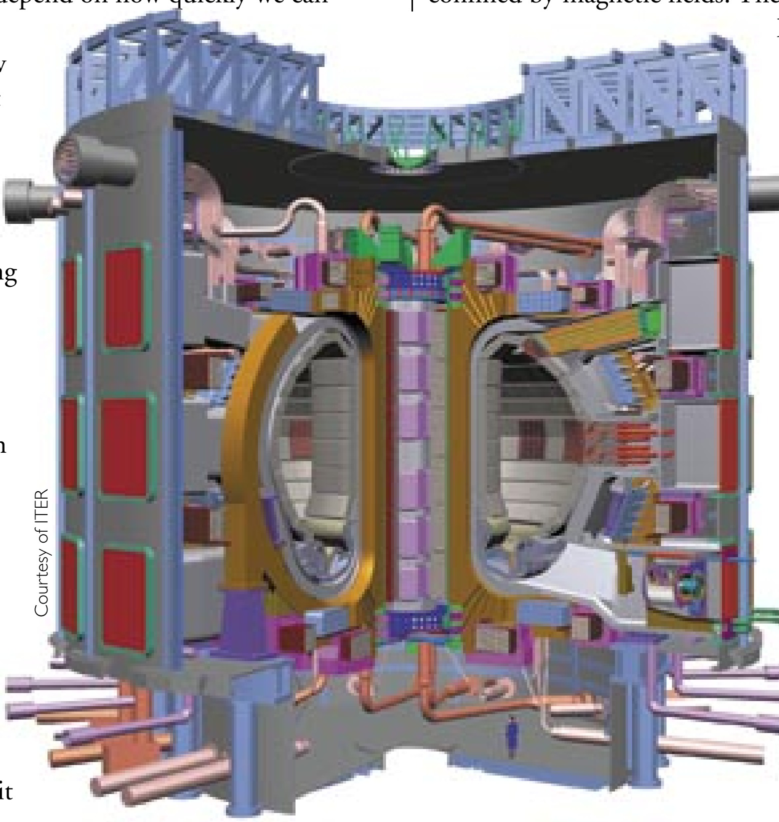
Holtkamp: ITER will be the first fusion reactor to create more energy than it uses. Scientists measure this in terms of a simple factor—they call it Q. If ITER meets all the scientific objectives, it will create 10 times more energy than it is supplied with. The latest device, JET in England, is a smaller prototype that in the final scientific stage reached a Q of nearly 1, which means that it generated as much energy as was put into it. ITER will be the way to go beyond this—a demonstration of creating energy in the fusion process—to a Q of 10. The idea is to put in about 50 megawatts and produce 500 megawatts. So part of the scientific goal of ITER is to first make sure that this Q of 10 can be achieved.

Another piece of the scientific goal is that ITER will have a very extended burn—an extended pulse of up to one hour. ITER is a research experiment reactor and cannot create energy all the time. When ITER starts operating, it will be on for up to one hour, then you have to turn it off. The importance of this is that, so far, typical devices we build can only have burn times of several seconds or tenths of seconds—that's the maximum. JET achieved its Q of 1 with a burn of about two seconds in a pulse length of 20 seconds. But several seconds is not really constant. Like starting a car—cranking the motor up and then turning it off is not really operating a car. When you drive your car for half an hour, it's constantly operating and demonstrates that you can actually drive.

So what ITER will provide technically and scientifically is a Q of 10 and an extended burn.

Q. What is the schedule for the ITER project?

Holtkamp: That will depend on how quickly we can put the team together in Cadarache, and how successful the different parties will be in constructing the components they have to deliver. That goes along with funding the project adequately on a yearly basis, so the funding needs to be agreed upon. The general intent is that in 2016 ITER will begin operation. I cannot promise you that this is realistic because the detailed planning process during the next year will have to confirm that. Therefore, I'm not quite willing to commit to 2016 yet. When complete, ITER will run for 25 or 30 years.



Courtesy of ITER

An artist's cutaway image of the ITER fusion device. The device is based on the tokamak concept, in which a hot gas is confined in a torus, or donut-shaped vessel, using a magnetic field. The gas is heated to more than 100 million degrees Celsius and will produce 500 megawatts of fusion power. A person at the bottom of the image gives an idea of the device's size.

Q. Could you describe the phases of ITER?

Holtkamp: Phase 1 is Before Construction. Officially, ITER doesn't exist yet as an organization because the seven parties have not signed and ratified the documents. That's supposed to happen by the end of the year. The parties have agreed upon what ITER as an international organization is going to look like. This is a real success story. It took four years or so to finalize the negotiations on how this is supposed to be done and that ITER will be built in France. At the same time, if you look at what the parties have said, the entire agreement document is less than an inch thick. It's impressive that seven parties can agree on founding a new international laboratory with less than an inch of paper.

We're launching the Construction Phase right now—constructing the device, building the buildings and pieces of the tokamak [a doughnut-shaped (toroidal) chamber used in fusion research in which a plasma is heated and confined by magnetic fields. The term tokamak is from the Russian words for "toroidal chamber in magnetic coils"], and then putting the tokamak together and getting it up and running.

The Operation Phase is the following 25 or 30 years, when all the experiments will be done. Because it's an experimental device, ITER will not achieve its performance the day after it's built. People have to learn how to operate it, where the tricks are, where the problems are, and they will have to push to achieve the ultimate scientific goals and maybe even go beyond.

Then the Decommissioning Phase starts; part of the construction and operation phases is to plan for decommissioning. I mentioned earlier that the fusion by-products are not very radioactive, but the chamber—the place where this process happens—is very radioactive. That needs to be decommissioned and disposed of in an environmentally compatible way, like any other radioactive piece of hardware. That's part of the decommissioning phase, which will last about five years.

Q. Why is international scientific cooperation critical to ITER?

Holtkamp: Energy is a problem for everybody in the world. If you look at the seven parties—the European Union, the Republic of Korea, India, China, Japan, Russia, and the United States—and count the people who live in these countries, they account for more than half of the world's population. The interest part is clear and can easily be explained. The scientific cooperation is just as clear in my view. There is expertise all around the world in fusion devices, and a complicated device of that magnitude absolutely needs the smartest people we can find to be successful. Plus, there's a big benefit in international cooperation because people of different cultures bring different ideas to the table, and in a scientifically competitive environment that leads to a better scientific device.

Q. What will happen at the end of the ITER project?

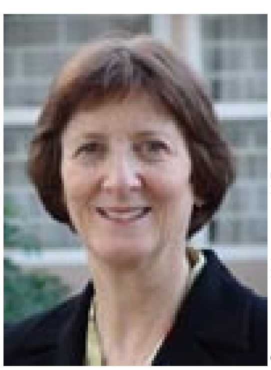
Holtkamp: The fusion program is very international, very widespread. People are already anticipating that ITER will be successful and are thinking about the next step—a prototype commercial fusion reactor called DEMO. In order to build that, ITER has to work. You have to achieve your scientific goals because that means the concepts you're putting forward are feasible. Nevertheless, I agree that one should always think ahead. Also, while ITER is operating over 25 to 30 years, the knowledge will gradually improve and grow, and the next step can be better defined. ■

The opinions expressed in this article do not necessarily reflect the views or policies of the U.S. government or the ITER parties.

BOTUSA
A Partnership in Disease Research

In Botswana, an Isoniazid Preventive Therapy Programme nurse shares a light moment with a client.

Courtesy of BOTUSA



Courtesy of Margarett K Davis, MD

Margarett K. Davis

Margarett K. Davis, MD, MPH, is director of BOTUSA, a partnership between Botswana's Ministry of Health and the U.S. Centers for Disease Control and Prevention.

The sub-Saharan African nation of Botswana is at the epicenter of the worldwide HIV pandemic. About 24 percent of the population between ages 15 and 49 carry the virus—one of the world's highest prevalence rates.

The 2006 *Report on the Global AIDS Epidemic,* issued by the Joint United Nations Programme on HIV/AIDS in May 2006, reported 18,000 deaths from the disease last year. Deaths of young adults in recent years have left 120,000 orphans, nearly 7 percent of Botswana's population.

AIDS is known as a fatal disease, but the actual cause of death for many victims is tuberculosis (TB), the most frequently occurring opportunistic disease that attacks the weakened immune system of HIV-positive persons. In fact, a study conducted jointly by U.S. Centers for Disease Control and Prevention (CDC) and Botswana researchers has shown that 38 percent of AIDS deaths in Botswana were actually due to TB.

The dual occurrence of TB and HIV infections is known as a co-epidemic. It is a painful burden for this landlocked nation of 1.7 million people, but the Botswana government is recognized for progressive and comprehensive policies to deal with the disease.

Since 1995, Botswana's Ministry of Health and the CDC have collaborated on programs and research to address the AIDS crisis. The partnership, called BOTUSA (pronounced bo-TOO-sah), involves more than 170 international, local, and support staff working to provide technical assistance, consultation, funding, program implementation, and research devoted to prevention, care, support, and surveillance of HIV/AIDS, tuberculosis, and related conditions.

The principal goal of BOTUSA's TB-HIV research is to expand knowledge of the relationship between epidemic tuberculosis and HIV disease in resource-constrained settings to develop better prevention strategies for TB control in Botswana and similar environments.

The major achievement of this more than 10-year-old research collaboration is a preventive therapy program. Using isoniazid, a proven TB preventive therapy, the program is attempting to prevent tuberculosis in up to 60 percent of people living with HIV. The Isoniazid Preventive Therapy (IPT) Programme, the first of its kind to be introduced anywhere in the world, is working to put all persons in the country living with HIV/AIDS on a preventive regimen of isoniazid to keep TB at bay.

Enrollment in the IPT program has also meant that HIV-infected persons are getting better access to care and antiretroviral drugs.

Health officials hoped the isoniazid treatment would provide a better-than-60-percent protection rate and longer lasting protection against active TB, however, so CDC and the Ministry of Health are conducting a trial involving 2,000 people to determine if continuous isoniazid therapy prevents more disease than the six-month course of drug prophylaxis.

Along with the latest projects, BOTUSA has produced a significant amount of research that has contributed to the world's body of knowledge about TB in the AIDS era, including surveys of drug-resistant TB, the population's TB infection rate, and the behavior and responses of patients and clinicians living amid a co-epidemic.

BOTUSA also provides more thorough training for Botswana's urban and rural health care workers, an activity that will result in improved disease surveillance, patient screening, and care.

Botswana is also one of 15 target nations receiving assistance under the President's Emergency Plan for AIDS Relief. The United States has provided funding for purchase of antiretroviral drugs and contributed to the development and implementation of national systems for training, quality assurance, and guidelines applied to clinical delivery of antiretroviral therapy, HIV laboratory, and monitoring and evaluation of antiretroviral therapy. These contributions have strengthened the success of Botswana's national strategy against AIDS. ■

GLORIAD: Cooperation in Research and Education

Greg Cole, Principal Investigator

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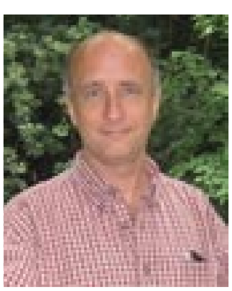
The control center at CERN—the European Organization for Nuclear Research, a frequent user of the GLORIAD network—combines all control rooms for the accelerators, the cryogenic system, and the technical infrastructure.

China, Russia, and the United States have joined forces to build and manage a fiber optic network that circles the Northern Hemisphere, creating a high-bandwidth Internet-like system that links scientists, educators, and students worldwide. The Global Ring Network for Advanced Applications (GLORIAD, http://www.gloriad.org)*, based at the University of Tennessee and the U.S. Department of Energy Oak Ridge National Laboratory, is funded by government agencies in the three countries and features partnerships with the world's most advanced research and education infrastructures in Canada, the Republic of Korea, the Netherlands, and five Scandinavian countries.*



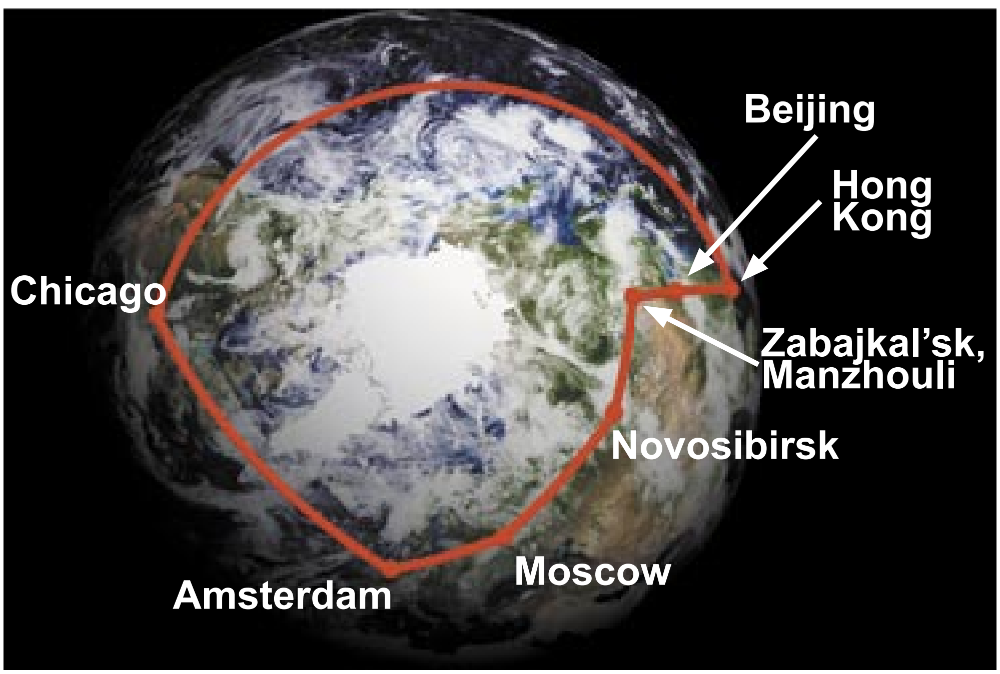
Courtesy of Greg Cole

Greg Cole

Greg Cole is principal investigator of the U.S. National Science Foundation program that established GLORIAD, and the program's predecessor, NaukaNet, with funding of $9.5 million (1998-2009). He co-directed (with Natasha Bulashova, now co-principal investigator of GLORIAD) the Ford Foundation-funded U.S.-Russian Civic Networking Program and directed other U.S.-Russia network infrastructure and community development programs funded by such organizations as NATO, the U.S. State Department, the Eurasia Foundation, Sun Microsystems, and others.

GLORIAD grew out of a successful U.S.-Russian initiative funded by the United States and Russia in 1997 to establish the first high-performance Internet between the U.S. and Russian science communities. The project, MirNET (later re-named NaukaNet), was a collaborative effort among the U.S. National Science Foundation (NSF); the University of Tennessee; the Russian Academy of Sciences; the Russian Ministry of Industry, Science, and Technology; and the Russian Research Center/Kurchatov Institute.

The idea was to connect research and education institutions in the United States via a major network exchange point in Chicago called STAR TAP—now called StarLight—with a similar facility in Moscow that connected nearly all research and education institutions in Russia. By establishing a fiber optic circuit across the Atlantic Ocean, Europe, and North America that connected the endpoints in Chicago and Moscow, we linked for the first time most major research and education institutions in the two countries.



Courtesy of National Science Foundation/T.Schindler

The route of an early version of the GLORIAD network that passes through Chicago, Amsterdam, Moscow, Novosibirsk, Zabajkal'sk, Manzhouli, Beijing, and Hong Kong.

Over the next several years, partnerships between U.S. and Russian scientists increased and network use grew dramatically. In 2003, we received permission from NSF to extend another connection to Russia, this time across the Pacific Ocean and, very importantly, through the People's Republic of China. We found partners connected in Hong Kong with our partners from the Chinese Academy of Sciences, then they connected the circuit from Hong Kong through Beijing and up to the Russian border near Khabarovsk. Our Russian partners extended their network to Khabarovsk, and Russia and China for the first time crossed their shared border with a telecommunications circuit. At that point, the ring around the Northern Hemisphere was complete.

The network was operating in early 2004. Later that year, NSF and our Russian and Chinese sponsors agreed to fund our new five-year program called GLORIAD, which expanded the service capacity of the ring around the Earth and implemented a new architecture for an advanced Internet. The new architecture lets us provide dedicated circuits to individual science collaborators that they can use for hours, days, or months, in addition to the shared services—like e-mail and videoconferencing—that we continue to provide.

In the last several years, science applications have grown to the point where some groups need the equivalent of their own Internet for a short time—either to move a lot of data or to ensure a quality experience, for example, in streaming high-definition video or remotely operating an electron microscope. The shared Internet is good for applications like e-mail that are not time or quality sensitive. But if you're remotely steering an electron microscope, you need an instantaneous response. That's one of the reasons we are building what we call a hybrid architecture with GLORIAD that allows us to provide dedicated circuits to scientists along with a shared Internet for their e-mail and Web applications.

The next step in developing GLORIAD was adding the Republic of Korea/Korea Institute of Science and

Technology Information as our fourth core member. They joined the project in 2005 and engineered and funded, thanks to the Korean Ministry of Science and Technology, a 10-gigabit circuit from Hong Kong, China, to Daejeon, Republic of Korea, to Seattle, Washington. This was the first piece of GLORIAD engineered to provide hybrid services. Our goal is to have the network operating around the Earth at 10 gigabits per second, and we're getting there one step at a time. With 10 gigabits per second, for example, we could support 25,000 videoconferences simultaneously, or roughly 1 million Internet telephone calls. Today, between the United States and China, and between the United States and Russia, we can support about a fourth of that.

The single biggest application running on GLORIAD at the moment is a connection between a high-energy physics institute in Italy and a cosmic ray detector facility, high in the mountains of Tibet, operated by the Chinese Academy of Sciences. An enormous amount of data is collected for analysis by scientists in Italy and China. That stream of traffic runs 24 hours a day. In the last hour, as I write this article, we've seen about 4 gigabytes of data travel between the sites.

Our second biggest application today is a data transfer from a NASA division, Engineering for Complex Systems, to the Chinese Academy of Sciences. We see a lot of space science research, particularly satellite imagery and atmospheric science data. Atmospheric sciences—climate scientists and weather forecasters—are among the heavier network users. These include the National Center for Atmospheric Research in Colorado, the Chinese Academy of Sciences in Beijing, and the Russian Hydrometeorological Center in Moscow.

We recently met with our GLORIAD partners in Moscow, where we learned about interesting telemedical applications. Our Russian partners have developed equipment that uses data from magnetic resonance imaging equipment to produce three-dimensional, life-size polymer models of patient organs, including the brain. It requires an enormous amount of data. These models are then used for analysis and for preparing appropriate surgical plans.

These are just a few examples of applications that you can't run over today's Internet, even with a broadband connection. That Internet just does not support the quality or throughput our science communities need.

One of the issues we deal with is cybersecurity—all the countries involved in GLORIAD try to deal with it collaboratively. We've developed some interesting applications that allow us to monitor use of the network, and we're developing some capabilities now to monitor abuse of the network. One of the problems we have at times is denial of service attacks, in which people orchestrate flooding a site, say in Moscow, with data from many sites around the world simultaneously, essentially shutting down the site. The sites receive so much data that the computing device can no longer keep up. There are many examples of how people misuse communications networks, and one important part of our effort in the United States is to research and implement safeguards against those abuses.

Throughout the project's development, network use has been limited to the research and education communities. Most of our customers are university researchers, but most of our traffic comes from national laboratories and other federally funded research facilities—including NASA, the Department of Energy, the National

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U.S., Russian, and Chinese scientists involved in the Compact Muon Solenoid Collaboration at CERN use the high-capacity GLORIAD network to transmit results of their experiments.

Oceanic and Atmospheric Administration, and the National Institutes of Health.

More than half our traffic today with Russia and China is sourced at federally funded facilities, where the big data archives reside. Most traffic is to and from our international partners—Russia, China, South Korea, and now the Netherlands, Canada, and the Scandinavian countries. Through a network called NORDUnet, our newest partners are Denmark, Sweden, Norway, Finland, and Iceland. NORDUnet is one of the most innovative networking groups in the world. They were involved in developing the early international Internet and have continued to be innovators in developing advanced network services. They will be contributing to GLORIAD a wavelength (a 10-gigabit-per-second circuit) from the Netherlands across Europe and to as close to the Russian border as possible.

In a sense, the network is about two things. It's connecting computers and instrumentation to allow scientists to share ideas and data, but it's also about improving our ability to communicate.

One thing for sure about GLORIAD, no matter how fast we move on increasing capacity and services on the network, the various science groups out there are moving faster. We're seeing many terabytes (1 trillion bytes) of data transferred each month and expect petabytes (1 quadrillion bytes) in the not-so-distant future. So it's a real challenge for us, but it's a good challenge. ■

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Internet Resources

Online resources for international scientific cooperation

American Association for the Advancement of Science (AAAS)
Award for International Scientific Cooperation
http://www.aaas.org/aboutaaas/awards/int/index.shtml

AAAS annually awards a $5,000 prize to an individual or small group that has made an outstanding contribution to international cooperation in science or engineering.

Bill & Melinda Gates Foundation
http://www.gatesfoundation.org/GlobalHealth

The Gates Foundation provides grants to established international organizations working to solve urgent health challenges in the developing world.

Carnegie Mellon University-Qatar Campus
http://www.qatar.cmu.edu

Carnegie Mellon, a highly regarded U.S. research university, offers undergraduate programs in business and computer science in Qatar. The university aims to provide an interdisciplinary, culturally sensitive course of study that will be among the leading programs in the region.

GlobalHealth.gov
http://www.globalhealth.gov

GlobalHealth.gov is an Internet gateway produced by the Office of Global Health of the U.S. Department of Health and Human Services. The site presents information on U.S. and international activities in this area, along with funding, employment, and training opportunities in global health.

International Council for Science (ICSU)
http://www.icsu.org/index.php

The council is a nongovernmental organization representing 107 national scientific bodies and 29 international scientific unions. ICSU sponsors international and regional networks of scientists working in related areas, acts as a discussion forum, and sometimes represents the global scientific community.

International Heliophysical Year (IHY)
http://ihy2007.org

The 50th anniversary of space exploration will be celebrated in 2007. In honor of this event, IHY has created a "Great Observatory" to advance understanding of the interconnected system of Earth, sun, and heliosphere.

International Space University
http://www.isunet.edu

The International Space University offers graduate training to future leaders of the global space community at its central campus in Strasbourg, France, and in locations around the world.

International Thermonuclear Experimental Reactor (ITER)
http://www.iter.org

ITER is an international research and development partnership designed to demonstrate the potential of fusion power.

Millennium Science Initiative (MSI)
http://www.msi-sig.org

MSI is a partnership of organizations and individuals promoting world-class science and engineering capacity in developing countries.

NASA
International Space Station—Science Operation News
http://scipoc.msfc.nasa.gov

Visit the International Space Station's NASA Science Command page for a variety of features on topics such as space science, mission status updates, expedition pages, astronaut biographies, video, Webcams, and partnership links.

Science.gov
http://www.science.gov

Science.gov is a gateway to authoritative science information provided by U.S. government agencies.

SciTechResources.gov

http://www.scitechresources.gov

SciTechResources.gov is a U.S. government database catalog that provides access to government resources focused on science, technology, and engineering topics.

U.S. Department of Energy Office of Policy and International Affairs

https://ostiweb.osti.gov/iaem

The Department of Energy International Agreements Database provides access to multilateral and bilateral science agreements involving the United States and other countries. The site also offers access to a publications library, speeches and testimony, and information about international scientific initiatives.

U.S. Department of Energy Office of Science Fusion Energy Sciences Program

http://www.ofes.fusion.doe.gov/internationalactivities.shtml

This site covers the international activities of the Fusion Energy Science Program, with related links to conferences and meetings, reports, and presentations. Also available on the site is information about the International Thermonuclear Experimental Reactor partnership and other international collaborations involving the Department of Energy.

U.S. Department of Energy Office of Scientific and Technical Information (OSTI)

https://www.osti.gov

OSTI aims to advance the diffusion of scientific knowledge and creativity at the national and international levels.

U.S. Department of State Bureau of Oceans and International Environmental and Scientific Affairs (OES)

http://www.state.gov/g/oes

The OES Bureau of the State Department has an extensive portfolio of issues including oceans, climate change, sustainable development, environment, science, technology, space, and international health. The Office of the Science and Technology Adviser to the Secretary of State is also located in this bureau.

U.S. Geological Survey Biology Partnerships

http://biology.usgs.gov/partnership/international.html

The Biological Resources Division of the U.S. Geological Survey is developing international partnerships in three key areas: sharing biological data, standardizing methodologies, and offering training and assistance to facilitate scientific exchange.

U.S. Global Climate Change Science Program

http://www.usgcrp.gov/usgcrp/about/international.htm

With support from the U.S. Global Climate Change Research Program, U.S. scientists and research institutions coordinate program activities with their counterparts in other nations. The United States is also party to several climate change cooperation agreements, both bilateral and multilateral.

U.S. National Institutes of Health (NIH) John E. Fogarty International Center for Advanced Study in the Health Sciences

http://www.fic.nih.gov

The Fogarty International Center advances the NIH mission through international partnerships and addresses global health challenges through collaborative research and training programs.

WiRED International

http://www.wiredinternational.org

WiRED International is a nongovernmental organization dedicated to providing health information and communications resources to developing and post-conflict areas of the world, now serving nearly 1 million people in 11 countries on four continents.

World Space Week

http://www.spaceweek.org/index.html

Established by the United Nations General Assembly in 1999, World Space Week is designed to foster international space cooperation and educate people about the benefits of space exploration. Participants in 50 nations celebrate the week October 4-10 each year with a variety of events.

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NASA astronaut Joseph Tanner waves toward the digital still camera of his space-walk colleague, astronaut Heidemarie Stefanyshyn-Piper, during extravehicular activity duties at the International Space Station on September 14, 2006.