THE BROOKINGS PROJECT ON
U.S. POLICY TOWARDS THE ISLAMIC WORLD

ANALYSIS PAPER
Number 8, March 2005

UNTAPPED POTENTIAL:
US SCIENCE AND TECHNOLOGY COOPERATION WITH THE ISLAMIC WORLD

MICHAEL A. LEVI AND MICHAEL B. D'ARCY

THE SABAN CENTER FOR MIDDLE EAST POLICY
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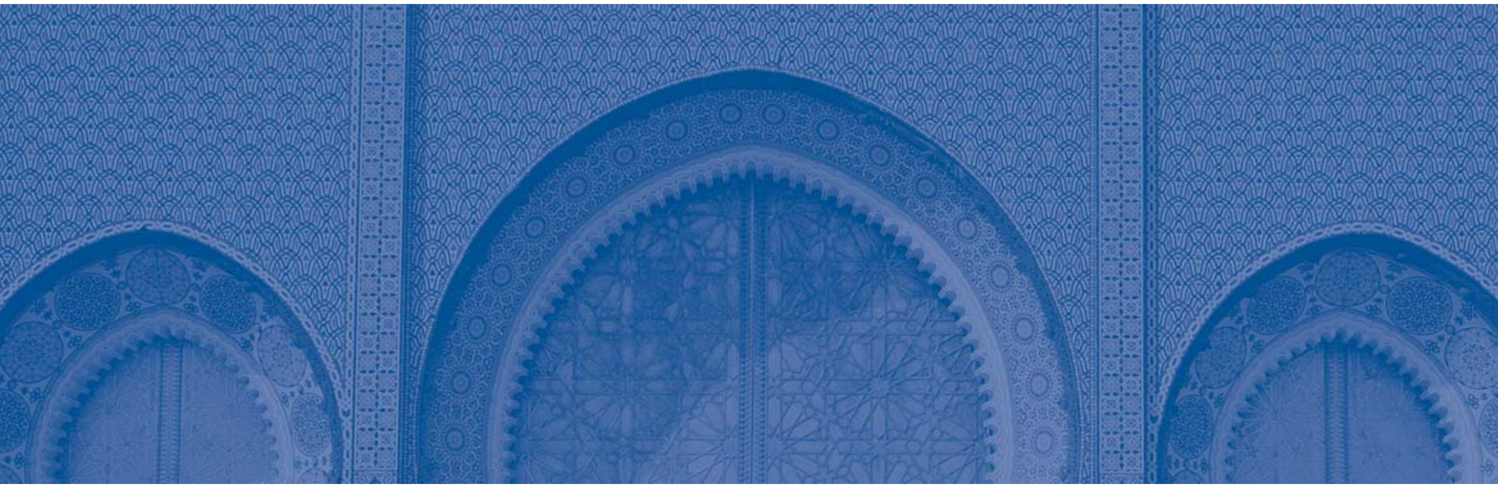

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Note from the Project Convenors

The *Brookings Project on US Policy Towards the Islamic World* is designed to respond to some of the most difficult challenges that the United States will face in the coming years, most particularly how to prosecute the continuing war on global terrorism while still promoting positive relations with Muslim states and communities. A key part of the Project is the production of *Analysis Papers* that investigate critical, but under-explored, issues in American policy towards the Islamic world.

The new US agenda towards the Muslim world is centered not just on how to find and destroy terrorist leaders and networks, but also on how best it can support positive change in a region suffering from a stagnant status quo. A widely recognized part of this program of change is bolstering human development, as a means towards undercutting the causes of and support for violent radicalism.

However, while science and technology has been an integral part of developmental success stories in East Asia, and science and technology cooperation was an essential aspect of US Cold War strategy, little understanding has been developed for how this key US strength—its strong science and technology resources and institutions—might be better utilized as part of its overall strategy towards the Islamic world.

As such, we are pleased to present *Untapped Potential: US Science and Technology Cooperation with the Islamic World* by Michael Levi and Michael d'Arcy. In applying the best of science knowledge to one of the toughest foreign policy challenges of our day, Levi and d'Arcy have filled an important research space. We appreciate their contribution to the Project's work and certainly are proud to share their views and analysis on this important issue with the wider public.

We are grateful for the generosity and cooperation of the Carnegie Corporation, the Education for Employment Foundation, the Ford Foundation, Lawrence Livermore National Laboratory, the MacArthur Foundation, the Government of Qatar, the United States Institute of Peace, Haim Saban, and the Brookings Institution for their support of various Project activities. We would also like to acknowledge the hard work of Sara Gamay, Zaid Safdar, Ellen McHugh, Sarah Yerkes, and Garner Gollatz for their support of the Project's publications.

Stephen Philip Cohen
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Executive Summary

America's relationship with the Islamic world, marred by widespread hostility that is manifested most devastatingly by terrorism, is a liability that cannot be ignored. In confronting it, efforts to destroy terrorist groups must be matched by initiatives that undermine radicalism, raise the standing of the United States and sap societal support for terrorists. These must remove reasons for terrorism and the context within which new recruits are drawn towards radicalism and violence. Economic and social development are important to realizing those visions—and science and technology can make critical contributions to such development. Nowhere is this sort of progress more urgently needed than in the Muslim states and communities that make up the wider Islamic world. Across a broad swathe from North Africa to East Asia, the Islamic world—with some important exceptions—not only lags behind global standards in economic, human, and political development, but is even farther behind in developing the science and technology capacity that can support sustainable future growth.

Despite widespread and growing public hostility to the United States in the Islamic world, American science and technology are widely admired there. This provides a valuable channel for productive cooperation. By working wisely with scientists and engineers from the Islamic world, the United States could bolster economic and human development and aid in tackling important regional problems like natural resource management, all while strengthening American public diplomacy in the Islamic world. To be certain, some science and technology cooperation, involving certain sensitive subjects, would be unwise, but a prudent balance is well within reach.

Only a strategic approach will yield the full potential benefits of science and technology cooperation, and the first foundation of that approach is a solid understanding of the state of science and technology in the Islamic world. There is no doubt that, even compared to other states at similar stages of economic development, states in the Islamic world lag in science and technology performance. Beyond that, no short summary can capture the immense diversity of the Islamic world, as no one country stands out overall. Malaysia is by far the strongest in applying science and technology to industry, while the Middle East dominates in academic publishing, and Central Asia stands out with its sheer number of scientists and engineers. At the opposite end of the spectrum, sub-Saharan Africa trails consistently. Moreover, strong institutions do exist even within weak states or regions, making cooperation possible.

Many would be surprised to learn that the United States already engages this scientific capacity over a wide range of fields. The US government has taken a strong lead in this area, working with scientists and engineers in nearly every state in the Islamic world, either through collaboration with US government scientists and engineers or by funding cooperative work outside the government. Prominent participants include the Department of Defense, Department of State, the United States Agency for International Development, the National Science Foundation, the National Institutes of Health, the Department of Energy, the Department of Commerce, the Environmental Protection Agency, and the Department of Agriculture. Private-sector efforts (by corporations and non-governmental organizations) have played a role, too, most prominently through donations and loans (from the World Bank, for example) for technological, agricultural, and educational development, through foreign direct investment in research and development, through corporate training programs (promoted by, for example, the World Business Council for Sustainable Development), and through the efforts of groups like the US National Academy of Sciences to build bridges with civil society. Furthermore, American universities host thousands of visiting Islamic world scientists every year. Indeed, perhaps without knowing it, the United States has built a broad and impressive program of science and technology cooperation with the Islamic world.

Despite these various initiatives, there is no coherent strategy, and with a deliberate effort the United States could do better. While it must be developed in collaboration with the scientific community, a strategy will require strong political guidance if it is to be an integral part of America's approach to the Islamic world. The United States should learn a number of lessons from past attempts at science and technology cooperation in the Islamic world and elsewhere:

- **Focus on applying technology, not just on scientific research and development.**
  With technological advancement the goal, research and development are often not the best focus. In many states education will be paramount; in others, the top priority should be to strengthen technology-intensive industry. Where research and development are possible, they should form a component of scientific collaboration. Technology, which leads to economic and societal development, should come first, though; research will follow in due course.

- **The political structure of scientific interactions matters.**
  Take care in structuring interactions, whether bilateral, regional, or spanning the Islamic world. Initiatives that cover broader areas may seem simpler and perhaps more cost-effective than bilateral approaches, but can be crippled by internal disagreement. They have met with success in some regions, such as Africa, but have faced greater difficulties in the Middle East.

- **Take advantage of Islamic world diasporas.** Many states have strengthened their science and technology capacity by drawing on their diasporas—not just their recent emigrants. Many areas in the Islamic world have substantial scientific diasporas in the United States, which could act as a bridge between the United States and their ancestral homes, and could therefore be profitably involved.

- **Develop a coordinated public diplomacy strategy.** With such a wide spectrum of activities already underway, and with broad respect across the Islamic world for American science and technology, it is simply negligent for the United States not to promote its cooperative accomplishments. A public diplomacy strategy will become even more valuable as cooperation is intensified.

- **Be modest in expectations of using science and technology cooperation to achieve policy changes.** Some have argued that science and technology cooperation might promote broad reform in Islamic world societies, through its emphasis on openness and by building links with the West. This objective cannot, however, be met by science and technology alone. The forces that prevent reform are strong, and will probably be overcome only with similarly strong tools. Nevertheless, while science and technology cooperation may not provoke major changes, it can aid in removing roadblocks to progress and is an underused tool in broader US policy.

- **Create an integrated arms control and nonproliferation strategy.** For cooperative science and technology to benefit American security, it must be approached in a way that does not spread the capacity to make weapons of mass destruction. During the Cold War, some major efforts in nuclear technology cooperation did the opposite. Such a result is not inevitable, but careful and vigilant strategy and planning, which address proliferation of both equipment and skills, are necessary to avoid it.

Within the context of a broader strategy, an expansion of American efforts will be beneficial. Individual programs ranging from a government-wide clearinghouse of science and technology cooperation to the execution of region-wide science and technology surveys would also be invaluable, serving as common foundations of a comprehensive strategy.

Though dollar figures are impossible to propose without far deeper exploration, there is no doubt that many opportunities await. In education, in industry, in research, in diplomacy, and in solving some of the immediate problems faced in the Islamic world, the potential of science and technology cooperation is immense. Fully exploiting it requires political leadership and must be made an urgent priority.

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Introduction

America's relationship with the Islamic world, marred by widespread hostility that is manifested most devastatingly by terrorism, is a liability that cannot be ignored. In confronting it, efforts to destroy terrorist groups must be matched by initiatives that undermine radicalism, raise the standing of the United States and sap societal support for terrorists. The reasons for which people become terrorists are still a matter of some debate—regarding, for example, the relative importance of poverty, social injustice, and the lack of democratic accountability in fostering extremism—but it is generally accepted that, in addition to political initiatives, economic and social development are critical in helping a society to overcome the conditions that breed terrorism.[1] Economic progress can alleviate the sense of overwhelming inequality that fuels resentment against the West; it can also provide meaningful work for skilled individuals who might otherwise turn to terrorism. Economic development also drives social progress: wealthier societies demand more from their governments, including the individual freedoms so lacking in much of the world.[2] Direct efforts to promote social development, such as providing clean water and adequate health care, can also help alleviate the resentment that can drive terrorism and terrorist sympathies. A broad consensus holds that such efforts, if they are to undermine terrorism in the long term, must be directed largely—though not exclusively—at the Islamic world.

These development challenges will not be successfully addressed without the spread of science and technology proficiency in the Islamic world (see Definitions section regarding the terms 'science and technology' and 'Islamic world'). The development darlings of the late 20th century—the so-called Asian Tigers (Taiwan, South Korea, Hong Kong, and Singapore)—achieved remarkable gains through technology-based strategies, and many rightly seek to emulate them. By using science and technology not only as consumers but as also producers, and by concentrating on exports of technology-intensive goods, they were able to dramatically increase income across society.

Other states have harnessed science and technology to more directly confront societal problems. For example, states in the Middle East have used water desalination technology to address critical water shortfalls, while states in sub-Saharan Africa have used science training to help their farmers better use fertilizer, thus improving agricultural yields.

1 See remarks of President Musharraf of Pakistan, December 6, 2004, <http://www.cnn.com/2004/WORLD/europe/12/06/musharraf.london/>, accessed December 30, 2004; Stuart E. Eizenstat, et al, "Rebuilding Weak States," *Foreign Affairs* 84 (January 2005); National Commission on Terrorist Attacks Upon the United States, *The 9/11 Commission Report* (New York: W.W. Norton and Co., 2004), 378–379.

2 When assessing the potential benefits of this development, optimism must be tempered by recognition of possible negative consequences such as societal upheaval and a resentment borne of meager economic progress in a freer market; nonetheless, the benefits could be considerable. Michael Mousseau, "Market Civilization and its Clash with Terror," *International Security,* Vol. 27, No. 3 (Winter 2002/03) pp. 5–29, and subsequent correspondence from Charles Knight, et al in *International Security,* Vol. 28, No. 2 (Fall 2003), pp. 192–198.

Nevertheless, scientific and technological progress continues to lag across the Islamic world. While differing in magnitude and detail from region to region and state to state, the presence of a deficit is consistent. This is not the case through any lack of intrinsic human or cultural capacity: science and technology flourished in the Islamic world long before rising in the West. For example, the "Golden Age" of the 'Abbasid period was notable for its flourishing study of science and mathematics. Indeed, the Islamic world of this period served as a repository for ancient Greek and Roman knowledge that would have otherwise been lost during Europe's Dark Ages. It is historical circumstances and poor leadership, not any inherent flaws in Islamic culture, that have produced the bleak situation prevailing today in the Islamic world. Yet that offers little consolation.

Compared to global standards, science and engineering education in the Islamic world tends to be weak. Few states in the Islamic world participated in the Trends in International Mathematics and Science Study (TIMSS), which tested eighth graders around the world; those that did scored consistently below average, and most languished at the bottom of the pack. At the university level, reasonable fractions of students generally enrolled in science and engineering courses, but low overall university enrollment made that mostly immaterial. Moreover, those students that did enroll very often received low-quality instruction.

Even those states with supplies of well-trained workers do not generally take full advantage of those skills. Quantitative data are primarily available for research and development, which encompass only a fraction of science and technology activity, but they are still enlightening. While developed states spend roughly 2–3 percent of their Gross Domestic Product (GDP) on research and development, states in the Islamic world rarely spend more than 0.5 percent. This is reflected in the low numbers of scientists working in research and development, and in the low rates of publications and patents.

Data on whether science and engineering graduates are using their skills in the marketplace—even if they are not engaged in research and development—are scarce. Anecdotal evidence suggests that in much of the Islamic world, with the possible exception of Southeast Asia, skills are not being put to optimal use. Since local ability to purchase high-tech goods is limited, the size of high-tech industry will be reflected in the volume of high-tech exports. Strikingly, while 17 percent of manufactured exports in the average low- or middle-income country are high-tech, only 2 states in the Islamic world (Malaysia and Tajikistan) reach that level. Only 6 others exceed even 10 percent. Even this dire statistic may overstate the Islamic world's level of science and technology development, as many states are dependent on extraction industries and have very small manufacturing sectors to begin with. Moreover, while governments often recognize that science and technology can be applied to address many local challenges—biodiversity conservation in Southeast Asia, water scarcity in the Arab states, and Soviet-era waste cleanup in Central Asia, to cite but a few examples—most states in the Islamic world do not have the scientific and technical strength to confront these challenges alone.

This deficit in science and technology capacity in societies with predominantly Muslim populations drags down development and thus presents a major challenge for US foreign policy in an era of tension and radicalism. At the same time, it provides an opportunity: by helping to raise the level of science and technology in the Islamic world, the United States could help sap the strength of terrorist and other radical movements, both by providing economic opportunity and social stability. It could also strengthen the badly battered US image in normally hostile parts, and is by no means inimical to long-term US economic interests.

This need to strengthen science and technology in the Islamic world has not gone unnoticed there. For example, the 2003 edition of the influential Arab Human Development Report (AHDR)—although covering only the Arab regions of the Islamic world—noted bluntly: "Data in the Report tell a story of stagnation in certain areas of knowledge production, especially in the field of scientific research."[3] It further reports that "societal awareness of the far-reaching importance of supporting scientists and science is extremely weak."[4] In response, the report exhorts Arab states to invest much more heavily in science and technology at every level, both financially and politically.

Members of the Organization of the Islamic Conference (OIC) have recently set up a Network of Academies of Sciences in OIC Countries under the leadership of Pakistani Science and Technology Minister Atta-ur-Rahman; the organization's vice presidents hail from Kazakhstan, Jordan, Malaysia, and Nigeria.[5] This will be an adjunct to the OIC Standing Committee on Scientific and Technological Cooperation (COMSTECH), which seeks to build member states' science and technology capacities.[6] The fact that these efforts have been made and that these concerns have been raised further underlines the opportunity that the United States now has for immersing itself in the scientific and technological development of the Islamic world, with all its attendant benefits.

This paper focuses specifically on the role that science and technology *cooperation* (see Definitions section) can play in achieving these shared goals. The international nature of contemporary science and technology means that these fields already play a significant role in fostering collaboration between different countries. Using science and technology cooperation to achieve foreign policy ends is certainly not a new technique for the United States; it was deployed extensively during the Cold War, on several fronts. It was used as an avenue for dialogue with the Soviet Union and China during the détente period in the 1970s and during the 1980s.[7] It was used to engage sympathetic scientists in Eastern Europe as the United States helped build civil society behind the Iron Curtain. Of particular relevance to present circumstances, it was also part of US engagement with Western Europe, through the Organisation for Economic Cooperation and Development in particular, improving the quality of life and thus minimizing the spread of pro-Soviet sympathies among Europeans. Each of these approaches was only part of a much broader diplomatic and security strategy—but in all cases, a science and technology dimension was present.

In the Islamic world, widespread hostility to the West results partly from the perception that people there are disconnected from progress that is being made elsewhere, and from a sense of dependence on foreign, more prosperous countries. Some of this lag in progress and persistent dependence is due to the large disparity in scientific and technological capabilities. US strategy during the Cold War carefully and successfully prevented such a wide divide from opening between the United States and Europe. Collaborating with scientists and engineers in the Islamic world could similarly dissipate hostility by increasing the technological self-reliance of Muslim-majority countries as well as by fostering in their populations a greater understanding of Western culture and achievements, based on a more equal relationship between the Islamic world and the West.

This paper begins with a general analysis of how science and technology cooperation might be used to achieve a spectrum of current foreign policy goals. It then turns to survey science and technology in the Islamic world, identifying scientific needs and aptitudes on a region-by-region basis. Against that

3 United Nations Development Program, *The Arab Human Development Report 2003* (New York: United Nations Development Program, 2003), 8.
4 Ibid., 73.
5 David Dickson, "Islamic states form network of science academies," *SciDev.net,* March 19, 2004, <http://www.scidev.net/News/index.cfm?fuseaction=readNews&itemid=1283&language=1>, accessed November 6, 2004.
6 COMSTECH, "Objectives", <http://www.comstech.org.pk/htm/obj.htm>, accessed November 6, 2004.
7 Norman P. Neureiter, "Talking with North Korea," *Science* 305 (September 17, 2004): 1677.

backdrop, it then looks at the state of US efforts that promote science and technology cooperation with the Islamic world, surveying both public and private activities. The paper concludes with a series of proposals for better addressing the challenge of encouraging the development of science and technology in Muslim-majority countries; the Appendix contains an indicative survey of some of the stronger science and technology institutions in the Islamic world.

Throughout, we consistently treat science and technology engagement as part of a broader US strategy for engaging the Islamic world. This means that we seek a possible science and technology component for America's Islamic world strategy, rather than an Islamic world component for America's science and technology strategy. Though advancing science and technology per se is important, it is not the primary interest here—instead, the priority is advancing America's relationship with the Islamic world. The policy impact of that difference is important.

The Potential of Science and Technology Cooperation

Science and technology are widely recognized as critical tools for lifting states and societies out of poverty. The East Asian experience is particularly instructive, and some organizations in the Islamic world—in particular, the authors of the AHDR—have advocated following this model. Beginning in the 1960s, South Korea, Taiwan, Hong Kong, and Singapore continually shifted to more technology-intensive export activities, while their economies grew at a tremendous pace. To be certain, other factors—such as high savings and protectionist trade policies—were at least as important in producing economic success. Nonetheless, technology was a key contributor.

The East Asian experience, however, also provides an important reminder that the most effective investment in science and technology may not be in research and development. Consider the South Korean case. The South Korean economy grew at a roughly constant rate of 8 percent annually, beginning in the 1960s,[8] even though South Korea's strong increase in industrial research and development spending did not begin until 1980. Even when South Korea began funding research and development, the focus was on advanced development, rather than on basic research.[9] Taiwan shows a similar trend, with meaningful research and development investments beginning in the early 1980s, and no major increases until 1985—despite a mean annual growth rate of 10.8 percent from the late 1960s into the early 1990s. The need to focus on science and technology broadly, rather than research and development, is a lesson that must therefore be kept in mind.

What can science and technology cooperation do to help put the Islamic world on a similar path? Much of the task of bolstering science and technology capacity in the Islamic world cannot be addressed through cooperative science and technology programs alone. Education reform, the foundation of any science and technology-based strategy, will require changes in university culture and staffing, as well as wide-ranging improvements in basic and high-school education. In many cases, innovation promotion will require legal, regulatory, and policy reforms. New money for new programs will often have to come from the governments of Islamic world countries, or, in other cases, from international donors such as the World Bank. In still more cases, the United States will contribute, but only through donations and assistance in policy formulation, not through cooperative ventures.

Nevertheless, cooperation can play an important role, not only directly but also in enabling and aiding these reforms. For example, the United States can employ

8 Jean M. Johnson, *Human Resources for Science and Technology: The Asian Region* (Washington, DC: National Science Foundation, 1993); <http://www.nsf.gov/sbe/srs/s1893/gdp.pdf>, accessed October 16, 2004.

9 World Bank Group, *The East Asian Miracle: Economic Growth and Public Policy,* (Washington, DC: World Bank Publications, 1993).

cooperation aimed at science teacher-training and textbook improvement to aid efforts to improve primary and secondary education. Exchange programs could also be valuable, bringing math and science teachers to the United States to learn American methods firsthand. Textbook reform is another area of primary and secondary education that requires cooperation, so that the product is properly targeted at the students' backgrounds. The value of education cooperation has recently been recognized in the 2004 Intelligence Reform and Terrorism Prevention Act,[10] which made funds available to increase US exchange, scholarship, and library programs relating to the Islamic world, and for grants to American-sponsored elementary and secondary schools in the Islamic world.

At the university level, capacity-building cooperation is best directed at graduate training and at research collaboration. Training graduate students from developing countries in the United States is a long-established tradition, and the learning that occurs when foreign students work with their American counterparts should be seen as a cooperative venture. Unfortunately, students from the Islamic world study in the United States less than do those from other states, with only a few significant exceptions. US policy with regard to the granting of visas to foreign students must also reflect the value of university-level exchange in science and technology development in the Islamic world—not to mention the benefits that the United States would also derive from the participation of these students in its intellectual life.[11] Some worry that by sending their best students abroad, states in the Islamic world would exacerbate a dangerous "brain drain," and indeed, policies should be crafted carefully to minimize that risk. At the same time, when students do remain in the United States, they often initiate collaborations with colleagues in their home countries and thus help to raise the standard of scholarship there.

Capacity building through research collaboration is also possible. Joint research facilitates learning, promotes the training of researchers, and encourages equipment transfer in many cases. According to a study by the RAND Corporation, collaborative research projects that successfully build capacity in the developing world have several key characteristics:[12]

- Successful collaborations work from the bottom up, are peer-reviewed, and result from shared interests.
- Collaboration is most successful when there is a basic level of capacity in place.
- Collaboration usually requires face-to-face meetings in order to initiate and negotiate the relationship.
- Capacity-building activities in developing countries are sometimes difficult to sustain.
- The presence of a few passionate leaders or champions can aid the success of the collaboration.

Science and technology cooperation can also be directed at addressing immediate local, national, and regional challenges. Such projects can address issues, such as uranium contamination in Central Asia, that threaten economic resources; in many cases, however, such work will not, on its own, lead to long-term economic development, as the technical skills learned may not be broadly applicable and the infrastructure needed to profitably harness them may not exist. This drawback should not exclude these ventures, though. If cooperation addresses sources of tension and instability—for example, water resources in the Middle East or environmental degradation in

10 Conference Report of the 108th Congress, "Intelligence Reform and Terrorism Prevention Act 2004, Sec. 7112" <http://www.house.gov/rules/s2845confrept.pdf>, accessed December 17, 2004.

11 See also Fareed Zakaria, "Rejecting the next Bill Gates," *Newsweek* (November 29, 2004), <http://msnbc.msn.com/id/6542347/site/newsweek/>, accessed December 17, 2004.

12 C. Wagner et al., "Science and Technology Collaboration: Building Capacity in Developing Countries?" RAND report MR-1357.0-WB (March 2001).

Southeast Asia—it can help build the right environment for successful economic development. Ventures in public health can help sustain the large, productive workforce needed for economic success. Furthermore, most cooperation on immediate challenges has a tangible humanitarian effect—a result not to be dismissed in a period at which US prestige and moral authority has suffered great setbacks.

Several guidelines should be kept in mind when pursuing science and technology cooperation on immediate challenges. First, as with development-oriented cooperation, the regional partner should be involved from the start. Indeed, when science and technology is applied to local or regional problems, it is rarely a strictly technical matter. Instead, solutions to challenges must fit existing social and institutional structures. For example, an initiative to produce clean water through the tap does no good if people will insist on using wells. The best way to avoid such difficulties is to involve local scientists and engineers at every stage.

It is also tempting to focus "needs"-based cooperation on global problems, such as climate change, since such projects appear to have the greatest direct payoff for the United States; they are genuine research and development, not just aid. However, such an approach is too narrow. The premise of US cooperation with the Islamic world is that local and regional conditions in the Islamic world are just as important to US welfare and security as traditional "global" issues. This should be kept in mind in assessing cooperative efforts.

Science and technology cooperation can also have important political and diplomatic benefits that are independent of its specific content, though it is important to be conservative in assessing its potential. Some argue that scientists play important political roles in much of the Islamic world, and that by engaging scientific communities on a positive agenda, the United States can mold a more friendly and progressive group of leaders for the future. The American experience with the Soviet Union is often cited as a case where transnational networks of scientists helped promote reform in an otherwise hostile state.[13] This is certainly a positive hope, but we should be modest in our expectations. The evidence that transnational scientific relations have directly prompted reform on their own is weak at best. In the case of the Soviet Union, much deeper economic and political trends placed Moscow in a precarious position, and Mikhail Gorbachev's personal calculations allowed the Soviet system to collapse.

In the Islamic world, analysts cite figures such as Pakistan's Science and Technology Minister Atta-ur-Rahman as an example of an elite scientist-turned-politician who has wielded significant power in a problematic regime. However, the preponderance of evidence indicates that Rahman's influence has been restricted to the sphere of science and technology, and not to other, more fundamental, political and economic matters. This sort of influence is not to be dismissed—but it should not be confused with broader political influence, either. We must also be aware that even if undemocratic regimes install scientists and engineers in influential ministerial roles because of their technical competence, accountability and democracy do not necessarily follow.

Science and technology are therefore important, but cannot be expected to stand on their own. They will be most successful when integrated into a wider, multifaceted strategy of engagement and development. For example, science and technology cooperation can have an important diplomatic impact if it is integrated into an effective public-diplomacy strategy. Polls show that, despite varying but low levels of support in the Islamic world for American policy in general, support and admiration for American science and technology is predominantly high. For example, a 2004 survey commissioned by the Arab American Institute and conducted by Zogby International found that majorities in Morocco, Jordan, Lebanon, and the United Arab

13 Matthew Evangelista, *Unarmed Forces: The Transnational Movement to End the Cold War,* (Ithaca, NY: Cornell University Press, 1999).

Emirates (UAE) were found to view US science and technology favorably, with the percentages having the favorable view being 90 percent, 83 percent, 52 percent and 84 percent, respectively.[14] Only in Saudi Arabia did a majority (51 percent) have an unfavorable view. The same Zogby poll showed that in all these countries, science and technology were deemed important by at least 40 percent of the population in shaping their attitude towards the United States, and this figure reached 75 percent in the case of Lebanon. This was in contrast to overall esteem for the United States falling as low as single digits in many Muslim majority states.

Highlighting the role of American science and technology in assisting Islamic world countries—and, as important, the ability of US and Islamic world scientists to work together as equals—projects a positive image of the United States which can help improve its stature in the Islamic world. To be successful, this should be done in a systematic and intensive fashion, rather than on an ad hoc, project-by-project basis. US public diplomacy deficiencies with regard to the Arab and Muslim world, and the need for a high-priority and systematic publicizing of US activities and achievements, have been highlighted.[15] Maximizing the public diplomacy benefit of US science and technology collaboration with the Islamic world must form part of any such strategy.

At the same time, science and technology cooperation is not without potential pitfalls. Two broad areas deserve careful attention. First, the United States must protect its economic interests. This means both being aware of the long-term impact of strengthening possible competitors and the short-term effect of potential patent and copyright abuse, and taking the steps necessary to manage those dangers. Second, the United States must take care not to promote the proliferation of dangerous weaponry, in particular weapons of mass destruction (WMD). This means considering the impact of a strengthened physical and human resource base in potentially hostile states, ensuring there are measures in place to adequately manage it, and withholding assistance when there are not.

14 Zogby International, "Impressions of America 2004," (Washington, DC: Zogby International, 2004), <http://www.aaiusa.org/PDF/Impressions_of_America04.pdf>, accessed December 30, 2004.

15 "Changing Minds, Winning Peace," Report of the Advisory Group on Public Diplomacy for the Arab and Muslim World (Edward P. Djerejian, Chairman), 2003.

Islamic World Capacity and Needs

We assess each region of the Islamic world using a set of national and regional statistics. This is supplemented by an Appendix which surveys a number of strong Islamic world institutions that are capable of collaboration.

We begin by looking at each region with broad measures of scientific and engineering activity. Most statistical indicators are incomplete, since many countries either do not track or do not provide data on their activities. The number of articles in refereed, international scientific and technical journals, since it can be assessed without assistance from the state, is available for every state, and provides the most consistent indicator of research and development activity, so we look at it first. To be sure, it is at best a relative indicator of science and technology strength, since the bulk of science and engineering is unlikely to result in new journal papers. We compare these numbers (as of 1999, or otherwise the most recent preceding year) to those for advanced states (590 annual articles per million residents for the United States, 380 per million for Japan) and for several middle income states: India (9 per million), Brazil (30 per million), and Mexico (20 per million).[16] Similarly, the number of scientists working in research and development gives a relative (but less complete) indication of science and technology strength in the various regions; we use the numbers for 2000, or the most recent preceding year.[17] As a benchmark, we compare to the United States and Japan, advanced states with 4,100 and 5,100 scientists in research and development per million population, respectively, and with India (160 per million), Brazil (320 per million), and Mexico (220 per million), all developing countries considered to have significant, though not world class, science and technology infrastructures. In some cases we also review total spending on research and development, when it can shed light on high or low research production;[18] as a comparison, advanced countries typically spend 2–3 percent of GDP on research and development.

One other way to measure Islamic world states' science and technology-intensive activities is to look at their technology-intensive exports; specifically, we look at exports classified as high-tech or medium-tech, as defined by the United Nations (UN) Industrial Development Organization.[19] These exports are

16 Data for numbers of journal publications are from 2004 World Bank, "World Development Indicator" (WDI).

17 Data for numbers of scientists are from the "United Nations Human Development Report 2003" (UNHDR 2003) (New York: United Nations Development Program, 2003), 274–277, cross-checked with the 2004 World Bank, "World Development Indicator."

18 Data for research and development spending are from the UNHDR 2003 (New York: United Nations Development Program, 2003), 274–277, cross-checked with the 2004 World Bank, "World Development Indicator".

19 Unless otherwise noted, we use the 2004 World Bank, "World Development Indicator" to assess high-tech exports as of 2002 (or the most recent preceding year), expressed as a percentage of total merchandise exports. We use the UN Industrial Development Organization, "Industrial Development Report 2002/2003," 165–166, to assess combined medium- and high-tech exports, as of 1998, given as a percentage of total manufactured exports.

defined as those that need not require significant research and development, but that do require technically skilled workers and managers. As a baseline, in high-income countries,[20] high-tech composes roughly 18 percent of merchandise exports, and in low-to-middle income countries, it composes roughly 10 percent of merchandise exports. Similarly, medium- and high-tech combined compose roughly 65 percent of manufactured exports in high- and upper-middle-income countries, 43 percent in lower-middle income countries, and 9 percent of such exports in low-to-lower-middle income countries, excluding China and India[21] (note that the value of medium-tech and especially high-tech goods *exported* will be close to the total value of *all* such goods manufactured in poorer states, including those in the Islamic world, because their domestic populations have less capacity to purchase these typically more expensive products). Given that, as we argue above, technology-based development is normally a higher priority than scientific research, this set of statistics is extremely important.

We turn next to education. Where data are available, we use the results of the TIMSS to assess the quality of secondary school science education.[22] We then review tertiary education, first noting the fraction of students in science and engineering courses, and comparing that to the typical fraction for advanced states, 20–30 percent.[23] We also look at the gross tertiary enrollment rate, since in many states a high fraction of students enrolling in science and technology is rendered irrelevant by the fact that very few residents attend any sort of higher education[24] (a similar observation sometimes applies to secondary school as well). Again, these figures are critical to technology-based development, even if students do not enter research and development; even improving elementary school education in mathematics and science expands a state's ability to pursue technology-intensive enterprise.

Shifting to look specifically at collaboration, we highlight the states in each region most involved in international research collaboration, and examine which partners they most often use. Though not all science and technology cooperation is in research, this still sheds light on which science and technology relationships are strongest.

Southeast Asia

Indonesia and Malaysia, the two major Southeast Asian states with Muslim majorities, present a very different image from the rest of the Islamic world. Malaysia is, without doubt, the most science- and technology-proficient state in the Islamic world; Indonesia is, in many respects, one of the strongest. Both states have aimed to expand their economies and their science and technology capacities through export-driven strategies. Brunei, on the other hand, is a small oil-rich sultanate that has more in common in its science and technology performance with comparable Gulf states. The Maldives are an archipelago with a GDP per capita comparable to that of Indonesia (yet a literacy rate of 99 percent).

Statistics for journal articles published suggest that Malaysia is much stronger in scientific research than Indonesia, with Malaysian researchers producing nearly 20 articles per million residents, similar to

20 The World Bank divides countries by Gross National Income per capita. For 2001, the threshold for the high-income group was $9,206 per person; middle income was $746–$9,206; and low-income was $745 or less. World Bank, "Global Economic Prospects 2003" (Washington, DC: World Bank, 2003), 221.

21 China and India, by virtue of their size, obscure broader trends when included with other low-income countries. Including India and China, low-income countries average 35 percent medium- and high-tech exports; aggregate data is available only for manufactured exports, not total merchandise exports. United Nations Industrial Development Organization, "Industrial Development Report 2002/2003," Statistical Annex, <http://www.unido.org/doc/24397>, accessed October 23, 2004.

22 TIMMS results below are from, "Trends in International Mathematics and Science Study (TIMMS)—Results," <http://nces.ed.gov/timss/results.asp>, accessed October 16, 2004.

23 Data below on tertiary science and technology enrollment is from the UNHDR 2003.

24 Data on gross enrollments given below is from the 2004 World Bank, "World Development Indicator."

Mexico or Brazil, while Indonesia produces slightly less than 1 article per million people, similar to much of the Islamic world. This is true despite the fact that the two states have similar numbers (per capita) of research and development scientists: Malaysia has roughly 160 for every million citizens, and Indonesia has roughly 200. This is sharply lower than advanced states like Japan, and also significantly lower than the Muslim-majority states of Central Asia, several of which have roughly 1,000 research and development workers for every million citizens. However, the numbers are comparable to India, Brazil, and Mexico, and are higher than almost all other Islamic world states. Promisingly, both states steadily increased their article output between 1994 and 1999 (the years for which data are available), Indonesia at an average of 6 percent per year and Malaysia at 5 percent. Brunei, on the other hand, produces 30 journal articles per million residents per year; this is similar to Qatar and the UAE, amongst the middle echelons of the Islamic world, while the Maldives produce only a rather low 5 articles per million residents. Both states' output neither rose nor fell dramatically over the 1990s. Statistics for the number of researchers are unavailable for Brunei or the Maldives.

Given that Indonesia and Malaysia spend 0.1 percent and 0.2 percent, respectively, of their Gross National Product (GNP) on research and development, roughly 20 times less than a typical advanced country, their statistics could be explained by a lack of trained scientists, but equally by a dearth of opportunities for their employment in research and development. (Why this results in so many fewer publications in Indonesia than in Malaysia is unclear. While Malaysia's GNP per capita is several times Indonesia's, the difference is not nearly enough to explain the productivity difference. Most likely, the difference is due to long-standing political unrest in Indonesia, skill differences amongst researchers, prudent investment of research funds, and possibly English language skill, which can affect journal submissions.) No data are available for the fraction of GDP spent by Brunei and the Maldives on research and development, but this could be expected to be similarly low, if not lower.

On the export front, 47 percent of Malaysia's merchandise exports are high-tech, and 65 percent are either medium- or high-tech, the latter statistic ranking it 6th in the world. Indonesia produces 5 percent of its exports in high-tech, and 16 percent in medium- or high-tech, ranking it 42nd in the world, behind only Malaysia and Turkey amongst Muslim-majority states. Moreover, both Malaysia and Indonesia have strong growth rates in these sectors, with medium- and high-tech exports growing 9 percent and 20 percent per annum respectively between 1985 and 1998. High-tech goods comprise 0.4 percent of Brunei's merchandise export revenue, a poor (though slightly uncertain) figure, similar to Oman, Egypt and Iran. No statistics are available for the Maldives.

Both Malaysia and Indonesia participated in the 1999 TIMSS, which assessed the quality of 8th grade education in an international sample,[25] though neither Brunei nor the Maldives participated. Malaysia scored near the middle of the pack, beating the United States slightly in mathematics, and doing marginally worse in sciences. Indonesia was much weaker, finishing behind, among others, Cyprus, Moldova, Jordan, and Iran in sciences, and behind those as well as Turkey in mathematics. No data on tertiary enrollments in Malaysia are available; in Indonesia, 28 percent of tertiary students are in science and technology, while in Brunei the figure is 6 percent. The latter proportion is extremely low, comparable only to Yemen and certain sub-Saharan African states. Overall tertiary enrollment in 2000 was 26 percent in Malaysia, 15 percent in Indonesia and 13 percent in Brunei, well below advanced-state levels. These numbers did, however, steadily grow during the 1990s, increasing roughly 50 percent for Indonesia and 100 percent for Malaysia and Brunei between 1995 and 2000.

25 "Trends in International Mathematics and Science Study (TIMMS)—Results," <http://nces.ed.gov/timss/results.asp>, accessed October 16, 2004.

Indonesia and Malaysia conduct some world class scientific research, and have significant institutional capacity to expand their international collaborations (Malaysia, for example, excels in applied solid state physics, while Indonesia is very strong in ecology.) Indonesian collaborations resulting in publications have been dominated by the United States, with fully 30–49 percent of international co-publications involving Americans; Dutch, Japanese, Australian, and British scientists have each been involved in 8–29 percent of Indonesian publications (we present these rather wide intervals because the RAND study from which the data are taken only contains ranges of percentages: 0–7 percent, 8–29 percent, 30–49 percent, and 50–100 percent). Malaysia has no distinct bias to any country, with 8–29 percent of publications involving each of the United States, Japan, Australia, and the United Kingdom. The diversity of collaborators for these two states is markedly different from the rest of the Islamic world, which tends to be dependent on one or two partnerships. No data for Brunei or the Maldives as regards scientific collaboration leading to publications are available.

This picture suggests different science and technology needs in Malaysia and Indonesia. Malaysia has no glaring deficiencies, and is particularly strong in education and in industry. Its main shortfalls appear to be in volume: it has fewer scientists than advanced countries, and spends less on scientific research; it also produces fewer scientists, not because too few university students choose science or engineering, but because too few young people attend university at all. Malaysia also has established scientific cooperation, which should make future collaborations easier.

Indonesia, while besting much of the Islamic world in many areas, still has many basic development steps to take. Improvements are needed from the bottom up. Science and math education in secondary school needs to be improved, and university education needs to become much more widespread across all subjects, including science and engineering. Compared to most Islamic world countries, Indonesia's industrial development is well advanced; still, it needs to strengthen its technology-intensive manufacturing capability, especially its medium-tech efforts. Those, in turn, rest on improved education and training (high investment in high-tech seems imprudent for a country at this stage). While having much room for progress, Indonesia does have a critical mass of scientists, and a host of established international linkages, which bodes well for future cooperation.

Data for Brunei and the Maldives are much more sparse. The number of journal articles per million residents in Brunei is respectable, despite the poor figures for enrollment in third-level education and especially in science and technology. The fact that Brunei is a small, oil-dependent state means that we might expect its general science and technology situation to be similar to that in analogous Middle Eastern states, meaning that there is a need for improvements in secondary and tertiary education, with high priority given to increasing science and technology study, and development of overseas partnerships. It is difficult to make any useful assessment of the Maldives with such scant data.

South Asia

This section primarily addresses Afghanistan, Pakistan, and Bangladesh. Though India is not, by our definition, an Islamic world state, its 12 percent Muslim population contains more Muslims—roughly 120 million—than any other country, aside from Indonesia and Pakistan. An understanding of the state of science and technology in this community is therefore important in seeking to obtain a full view of Islamic world science and technology. Measuring this state is difficult, however, as no religion-specific statistics are kept. We can, however, estimate some bounds on basic quantities like the number of scientists in research, and compare those to the rest of the Islamic world.

India has 157 researchers in research and development per million residents, which translates to roughly

190,000 researchers in the country.[26] If Muslims are represented in elite professions in proportion to their share of the Indian population, as suggested by South Asia scholar Stephen Cohen, this would imply roughly 23,000 Muslim scientists in Indian research and development.[27] This is double the number in neighboring Pakistan, and is similar to the number in Turkey, while it is roughly half the number in Iran.[28] If Muslim scientists in Indian research were only a quarter of this estimate—roughly 6,000—that number would be similar to Bangladesh or Malaysia. Though this is only one statistic, and does not reflect industrial, non-research work, it strongly suggests that future studies should attempt to assess India in greater detail; this will probably require detailed survey work, or at least broad sampling to determine the relative role of Muslims in various spheres of Indian scientific and engineering life. (A notable aspect to explore, and potentially leverage in broader policy, is the relative success of Indian Muslim business leaders in the hi-tech sector. Success stories such as Azem Premji, the chief executive officer of Wipro Technologies and one of the richest men in the world, demonstrate that Muslims can be science and technology leaders on the world stage.)

Useful data for Afghanistan are nearly nonexistent—given the present unstable state of the country, a focus on basic aid rather than science seems reasonable for the near-term, with science collaboration occurring only in education, and, even then, sparingly. For that reason, we focus our analysis of the science landscape in South Asia on Pakistan and Bangladesh.

Neither the Pakistani nor the Bangladeshi system produces many journal articles, with Pakistan yielding roughly 2 for every million residents, and Bangladesh yielding 1 per million, the weakest numbers in the Islamic world, including sub-Saharan Africa. They are similar again in proportional numbers of scientists, with roughly 50 and 70 per million, respectively; this coincides with the weaker Middle Eastern states, and is no different from some cases in sub-Saharan Africa. One differentiating point is research and development spending, with Pakistan now nearing 1 percent of its annual GDP—very high for a developing state, but still low in global terms (Bangladesh does not report a research and development figure). Output, measured in journal articles, was fairly steady in both countries during the 1990s.

In high-tech exports, a similarly weak pattern continues, with Pakistan again maintaining a small advantage: 0.3 percent of Pakistan's merchandise exports are high-tech, while 0.2 percent of Bangladesh's are, both near the bottom of the Islamic world. Pakistan fares much better when medium-tech exports are included, with the share increasing to 9 percent; not so Bangladesh, whose share increases only to 3 percent. Between 1985 and 1998, Pakistan's level grew by an average of 1 percent per year, while Bangladesh's grew by roughly 4 percent per year. The present Pakistani numbers place it near Egypt and Venezuela—weak, but not terrible. The Bangladeshi numbers are near the bottom of the pack.

As would be expected, the educational foundation in these states is weak compared to global standards. Neither country participated in TIMSS. In Bangladesh, though, only 44 percent[29] of residents attend secondary school at all, making quality a lower-order issue (no data are available for Pakistan, though its primary school enrollment level from 1990, the only figure available, is even lower than Bangladesh's, and even fewer students must attend secondary than primary school). No data on tertiary students exist, either science and technology-specific or other. Between 30 percent and 49 percent of international collaborations involve Americans; Germans and Britons are each involved in 8–29 percent as well. Both Pakistan and

26 "UNHDR 2003", 182.
27 E-mail correspondence between Michael Levi and Stephen Cohen, December 23, 2004.
28 2004 World Bank, "World Development Indicator."
29 "UNHDR 2004" (New York: United Nations Development Program, 2004), 178.

Bangladesh, then, have a science and technology deficit in nearly every area.

Although in the popular imagination Pakistan is often seen as being more scientifically advanced than Bangladesh, the figures belie that impression. The perception may arise from Pakistan's nuclear program, which gives it an aura of scientific sophistication. That program, however, is not particularly technologically advanced; and in any case, much of it is based on copied technology. Bangladesh also has its own pockets of strength, particularly in agricultural science. In neither case, though, do those isolated strengths make up for broader, systemic weaknesses. Both states lack the key foundation for science and technology success: comprehensive, quality, basic education. This is not a science-and-technology-specific necessity, though as access to schooling grows, it is, of course, important to ensure quality in science and technology education. This need can only be addressed by much broader education policy reform, something generally outside the science and technology realm. Until it is addressed, other science and technology-based efforts will be limited.

Nonetheless, there is potential for engagement on other fronts. Both states have few scientists, but enough to enter cooperative ventures—boosting the number of trained scientists would be useful. Moreover, while both states would benefit from improvements in industry, it is doubtful that those improvements could be made without strong improvements in education.

Central Asia

The state of Central Asian science and technology is predominantly influenced by its former place in the Soviet Union. As a result of the Soviet Union's investments in science and technology, these states boast far greater numbers of trained scientists and engineers than other Islamic world states—but most of them are aging and are out-of-date in their training. Likewise, the states own much technical equipment, but it is mostly old and of usually limited utility for current scientific challenges. Journal publications range from 1 (Turkmenistan) and 2 (Kyrgyzstan) per million to 7 (Kazakhstan) and 10 (Uzbekistan) per million, with the upper end of the range similar to India but still short of Mexico and Brazil. This is also at the lower end of the spectrum for Islamic world states, despite there being very large numbers of scientists in research and development. Numbers range from roughly 400 per million (Kyrgyzstan) to 1800 per million (Uzbekistan), higher than almost all Islamic world states and also developing states like India and Brazil, though still poor compared with the developed world. As for most Islamic world states, research and development spending is low (0.2–0.6 percent of GDP), so there may be far more science- and technology-trained workers than research and development employees. These statistics suggest a large reservoir of inadequately exploited human capacity. It is also worth noting that Kazakhstan, Kyrgyzstan, and Tajikistan all showed steady decreases in journal publications during the 1990s; data for Turkmenistan and Uzbekistan show no discernable trend. Although the civil war in Tajikistan is almost certainly a factor in that country's declining performance, these statistics reinforce the notion that Central Asia's scientists have not been able to fully adjust to the post-Soviet era and thus are doing work less relevant to general science than before.

Export figures can, again, shed some additional light. Though data are sparse, it appears that no state exceeds 10 percent high-tech products within its manufactured exports, comparable with the stronger non-oil-dependent states of the Middle East and North Africa, but still well below the low- and middle-income state average. During the late 1990s, Kazakhstan's high-tech exports steadily increased; no reliable data are available for its neighbors. Refined data on medium-tech exports are not available.

The education front is difficult to gauge, too. No Central Asian state participated in TIMSS. At the tertiary level, two states report data on science and technology enrollments: 23 percent of Tajik tertiary students are in science and technology, similar to advanced countries, while 42 percent of Kazakh tertiary students are in science and technology, among the highest figures of any state. Statistics on total enrollment in tertiary studies are spotty, but appear to vary from roughly 20 percent of the level for advanced states (Uzbekistan, Tajikistan) to 70 percent (Kazakhstan, Kyrgyzstan), the latter cases being exemplary. These statistics reinforce the observation that Central Asia's body of trained scientists and engineers is its greatest science and technology strength. Measures of visiting students and researchers in the United States are neither the highest nor the lowest in the Islamic world, but range over the middle, with Kyrgyzstan and Kazakhstan strongest (comparable to Turkey or Indonesia), and Tajikistan and Uzbekistan weakest (comparable to Mali and Morocco).

Detailed data on patterns of research collaboration exist only for Uzbekistan, but are enlightening. When Uzbek researchers collaborate internationally, they do so predominantly with Russian colleagues—a full 30–49 percent of international publications involve Russians. The 2 other significant partners are the United States and Germany, each appearing on between 8 percent and 29 percent of collaborative Uzbek papers.

Despite the overall weak picture, the Central Asian states have some extremely strong science and technology institutions. Foremost are those formerly involved in weapons of mass destruction, particularly nuclear and biological weapons, whose skilled workers, if not equipment (which is obsolescent), could be turned to other uses.

Central Asia's needs, then, are distinct from those of the previous two regions. Education does not appear to be a weak point relative to the rest of the Islamic world, though a quality assessment of both secondary and tertiary education would be valuable. The main challenge in Central Asia is matching scientists to worthwhile science and technology work and to funding; providing advanced training to make those matches possible will also sometimes be necessary. Central Asia faces a host of development challenges, a proper discussion of which is beyond the scope of this paper, but to address which, as often as not, requires science and technology. Here, the science and technology needs are funds, equipment, and training. On the industry front, the Central Asian states may need help in matching training to industrial needs, in technology licensing and adaptation, and in choosing technologies and industries on which to focus. Success, of course, will also depend on other policy decisions (economic, monetary, and trade policy in particular), and no amount of science and technology collaboration will make up for poor higher-level policy.

Middle East

The states of the Middle East range from some of the strongest science and technology performers in the Islamic world to some of the poorest. Somewhat surprisingly, states do not, for the most part, divide into oil-dependent and non-oil-dependent states. While oil revenues may remove incentives to train a modern workforce, they can also provide the funds to support science and technology activities. A much better predictor is wealth: richer states have generally stronger science and technology systems.

Journal article data are much more complete than any other statistic in this region. Four states are anomalous: Kuwait, with 123 publications per million residents (the only Islamic world state above the world average of 88), and Libya, Syria, and Yemen, with low levels of 3.7, 3.5, and 0.6 publications per million residents, respectively (comparable to South Asia, but worse than all other parts of the Islamic world, apart from Sub-Saharan Africa). The remaining states yield between 10 and 50 publications per million residents, broken into three groups: lower (10–25: Iran, Egypt, Lebanon—comparable with North Africa and Malaysia, and similar to the low- and middle-income state average), middle (26–40: Saudi Arabia, Qatar, UAE—better than all other Islamic world regions, comparable to Mexico and Brazil), and upper (41–50:

Jordan, Bahrain—approaching the world average). Among those states for which data are available, statistics on numbers of researchers divide into two groups. The strong performers range from Kuwait, with 220 researchers per million, through Libya (360), Egypt (490), Iran (590), and Qatar (590). Note that the same states are strong in publications, though not in the same order. No other state for which figures are available exceeds 100 researchers per million. Some examples include Oman (4), Syria (30), and Jordan (90).[30] Spending on research and development is uniformly low, with figures ranging from 0.2 percent of GDP (Egypt, Syria) to 0.5 percent (Iran).

Examining trends in journal publications splits the region into two sharp groups. The first—Iran, Jordan, Kuwait, Lebanon, Oman, UAE, and Yemen—showed steady growth during the 1990s in total journal publications; indeed, in all these cases, this outpaced population growth. In no other state in the region did the publication total grow significantly, even ignoring population growth. Strong decreases were encouragingly rare, though, posted only by Bahrain and Saudi Arabia.[31] Elsewhere in the region output was flat, or the data were insufficient to make an assessment.

A review of high-tech exports reinforces the region's weak human development image that has been cited by the Arab authors of the noted United Nations Development Program (UNDP) reports on Arab development. States again separate into groups, but along different lines from before. Only two states create more than 1 percent of their merchandise export revenue through high-tech goods: Jordan (4 percent) and Lebanon (2 percent), neither of which is able to depend on oil exports. An intermediate category includes Oman (0.4 percent), Egypt (0.2 percent), and Iran (0.2 percent), a mix of oil-dependent and other states. Several other states with reliable statistics fare even more poorly: Qatar (<0.01 percent), Saudi Arabia (0.04 percent), and the UAE (0.05 percent), all of which rely on oil and gas exports. While these statistics clearly separate those states with stronger science and technology capabilities, they also reveal a consistent pattern of high-tech manufacturing falling behind even low- and middle-income state standards in the rest of the world. More refined statistics, covering middle- and high-tech exports, add only a few wrinkles to the pattern, and no state in the region exceeds 10 percent in this measure. Egypt is strongest, with 9 percent and a world rank of 54th, while Oman, Bahrain, Saudi Arabia, and Jordan all have 5–6 percent and ranks of 54th–60th, again cutting across the oil-dependent/non-oil-dependent split. Every state in the region could potentially benefit from more technology-intensive manufacturing.

Among those states with historical data for medium- and high-tech exports, we can also look at trends. Several states show per-annum increases from 1985–98: Egypt (21 percent), Saudi Arabia (9 percent), and Jordan (8 percent). In contrast, Bahrain showed an annual 2 percent decrease over those years, and Oman an annual 9 percent decrease.

The results of TIMMS offer insight into pre-university science and technology education in a few select countries. Jordan and Iran participated; both performed similarly, scoring low but not last, beating, for example, Indonesia and the Philippines, but falling behind Macedonia, Israel, and Malaysia. At the tertiary level, things appear somewhat better. Amongst those states with data, all but three have science and technology enrollment rates over 20 percent, the level typical of advanced countries. Two states—Egypt and Saudi Arabia—fall short, but not by much, with levels

30 While the "UNHDR 2003" reports 1,950 researchers per million residents for Jordan, the underlying WDI data appear extremely unreliable. In particular, for the same year that the figure is reported, the WDI lists Jordan ranked first in the world in research and development spending per unit GDP, with a level more than twice the second country, suggesting that the statistics should not be trusted. RAND reports the 94 researchers per million figure based on a European report, a number more in line with overall Jordanian science and technology.

31 Interestingly, this negative indicator is, in the case of Saudi Arabia, in agreement with the trends exhibited by other measures (e.g. GDP per capita), all of which may betoken a society experiencing widespread difficulties.

of 15 percent and 18 percent, respectively. Only Yemen, with a rate of 6 percent, can be said to seriously lag, and this likely results less from a specific policy failure than from Yemen's overall impoverished state. The science and technology enrollment rates just cited are on a gross enrollment base of normally 10–25 percent (about one-third of the advanced state level), though Jordan (31 percent), Egypt (37 percent), and especially Libya (60 percent), are exceptions.

International collaborations resulting in publications are dominated by work with the United States, which is the most common collaborator for all states with significant publication records. In most of those states—specifically Egypt, Iran, Kuwait, Saudi Arabia—between 30 percent and 49 percent of international publications involve Americans. The United Kingdom is the other consistent presence, with every major state in the region, save Egypt, showing 8–29 percent of its international papers coauthored with British scholars. The only other states playing significant roles are Germany (with Egypt and Jordan), and Japan, Australia, and Canada, all with Iran.

It is impossible to prioritize general needs for the region, but some general observations are appropriate. The TIMMS survey suggests that education quality needs to be improved; the data are for the secondary level, but a similar need at the university level can be inferred. Improvements in tertiary science and technology education would be most effective if overall tertiary enrollment could be improved. The region would also benefit from improved training abroad, requiring an effort to boost scientific training in the United States for scientists from lagging countries.

Most states in the region have sufficient scientific strength to collaborate on development-related projects. The generally low numbers of scientists suggest little ability to find the "critical mass" of scientists needed to make specialized projects succeed autonomously, but by using international collaboration, such success appears possible. Research and development spending is very low, but there is no indication that, absent broader training and collaboration, a simple increase in research and development spending would yield significant results.

Several states in the region—Egypt in particular—have had a measure of success with medium- and high-tech exports. They would benefit from continued engagement on that front. In the rest of the region, basic education on the value of technology-based exports is needed, as is, perhaps, assistance in matching training and investment to technology-intensive manufacturing. Again, though, success in this area will require improved education.

It should be noted that Yemen stands aside on almost all measures, and its current shortcomings will be compounded by the rapid population growth that it is experiencing. Basic improvements outside the science and technology realm, in areas such as education, health, and safety, are required before any significant science and technology advances can be made. As this development takes place, science and technology may be involved along the way—for example, in ensuring quality math and science education as broader education is extended and improved—but it will be not be a central plank in the process.

North Africa

If Central Asian science and technology is dominated by its connection to Russia, so North African science and technology is dominated by its connection to France. It is also shaped by natural resources: Algeria's oil wealth has removed pressure to turn to science and technology, but has not generated enough wealth to make science and technology investments natural (nor, for that matter, has it forestalled the civil conflict that has hampered science and technology along with everything else). For the most part, Algerian science and technology is at a similar level to that in the weaker Middle Eastern states, while Tunisian and Moroccan science and technology is similar to that in the stronger ones. Most promisingly, the French relationship has yielded a set of strong institutions that can form the basis for collaboration.

Production of journal articles ranges from 25 per million people for Tunisia, through 13 per million for Morocco, to 5 per million for Algeria; these numbers coincide with the bottom half of Middle Eastern countries, or, alternatively, with Malaysia. All these numbers were steadily on the rise during the 1990s, with average annual increases in total journal articles between 1994–9 of 6 percent (Algeria), 17 percent (Morocco), and 13 percent (Tunisia). Data on the number of scientists in research and development exist only for Tunisia, which has 125 per million, similar to Jordan, India, or Mexico.[32] Again, only Tunisia has data for research and development spending, with 0.3 percent of GDP, well below advanced-state levels.

Better data are available on the export front. Algeria, rich in oil, performs poorly, as expected, with only 0.1 percent of its merchandise export revenues coming from high-tech exports, last amongst Islamic world states. In contrast, 3 percent of Tunisia's exports are high-tech, as are 7 percent of Morocco's, still low compared even to the average low- or middle-income country, but, in Morocco's case at least, approaching that level. Data for medium- and high-tech exports confirm the trend, with Algeria ranked near-last at 84th, with less than 1 percent of its exports in this category, and Tunisia and Morocco ranked 43rd and 49th, with 16 percent and 12 percent high-tech exports, respectively. Promisingly, between 1985 and 1998 Algeria's total increased by an average of 4 percent per year, Morocco's by 3 percent per year, and Tunisia's exports were nearly constant (with Algeria's totals so low, though, one cannot put too much faith in their accuracy). The current figures are similar to Indonesia, India, and most of the Middle East but significantly lower than Turkey, South Africa, or Brazil.

TIMMS data are available only for Morocco, which performed poorly, placing second-to-last, ahead of only South Africa. Data on tertiary enrollments in science and engineering are more comprehensive, and all states in the region have large fractions of students in those areas, ranging from 27 percent for Tunisia to 50 percent for Algeria. Again, though, these balances are made less valuable by the fact that no state has more than about 20 percent gross tertiary enrollment overall, compared to 50–70 percent for advanced states. Algeria, for example, while having 50 percent of its students in science and technology has only 15 percent of its people enrolling in tertiary education, so a net 8 percent of all individuals get a higher education in science and technology; for Morocco, that net figure is only 3 percent, while for Tunisia, it is 6 percent.

Publications resulting from international collaboration stand out from the rest of the Islamic world: whereas in other regions collaboration is dominated by the United States and, to a lesser extent, the United Kingdom, here it is overwhelmingly dominated by France. All three North African states perform over 70 percent of their international collaborative publication with France. Algeria and Tunisia perform no more than 7 percent of their collaboration with any other state, while Morocco involves the United States in 8–29 percent of its collaborative publications.

North Africa thus presents two sets of needs: one for Algeria, and another for Tunisia and Morocco. As Algeria stabilizes in the coming years, it will have the option of increasing its investment in technology-intensive manufacturing. A lack of past investment should not stop it from achieving the same level as Tunisia or Morocco; indeed, Algeria produces more trained scientists and engineers than either of its neighbors. However, it is far from clear that the Algerian government will see a need to shift from a resource-based economy to a manufacturing one. If it does, then, in making that transition, it would benefit

32 Note that the UNHDP reports 340 researchers per million residents. However, WDI data suggests this numbers is anomalously high—data in this range are reported only for 1997–1998, nearly tripling from 1996 to 1997. Moreover, this jump is accompanied by a similar reported jump in research and development spending, which is sustained only until 1999, before returning to previous levels in 2000–2002 (research and development spending data is available through 2002, where researcher data stops in 1998). The most plausible explanation for this is that all data were reported high in 1997–1999; thus, we use the 1996 datum on the number of researchers.

strongly from assistance in planning, training, and management. At the same time, science and technology collaboration with Algeria in solving immediate problems could be fruitful, and would benefit from a substantial supply of trained scientists.

Morocco and Tunisia are on a different path, having already shown the impulse to invest in high- and medium-tech manufacturing. However, they still need to advance significantly if they are to reach the world average in high- and medium-tech exports. Their education systems could do to produce more trained scientists at all levels, and if Morocco's TIMMS results are an indication, they require improved quality in science education. At the same time, overall enrollment must improve. Tunisia is perhaps furthest ahead, and, indeed, was deemed more advanced than its North African neighbors by a visiting State Department Assessment Team in the fall of 2003.[33] This assessment found it having "shown significant success in the application of science and technology to promote economic development and promote sound environmental stewardship."

Sub-Saharan Africa

The Muslim-majority states of Sub-Saharan Africa share the same development problems as their generally impoverished non-Muslim neighbors; unsurprisingly, their science and technology infrastructures lag.

They produce few journal articles compared to global standards, with few exceptions. Only two states averaged over 3 articles per million residents: the Gambia (18) and Senegal (7); even these numbers place them near the bottom end of the Middle Eastern states. Fully half of the states averaged only 1 or less articles per year. The trends in journal articles are inconsistent. Many states have data too erratic to infer trends from; among those that do have a discernable trend, however, all showed steady increases between 1994 and 1999. There is little reporting on the number of researchers in the region, but the two states that have reported in the last decade—Burkina Faso and Senegal—have only 16 and 2 researchers per million residents, respectively. What little data on research and development investments exist only follow this trend, with Burkina Faso investing 0.2 percent of its GDP.

Among the Islamic world states of Sub-Saharan Africa, only in Senegal and Burkina Faso do high-tech goods comprise 1 percent or more of merchandise exports. Data on medium- and high-tech goods are only available for Senegal, which is near the lowest in the world, with 1.4 percent of its exports in that category, and an annual decrease of 12 percent from 1985 to 1998 (it is striking that, despite this, Senegal appears to be one of the *strongest* Islamic world states in science and technology in Sub-Saharan Africa).

No Sub-Saharan African states participated in TIMMS. Only 4 states report figures for tertiary students in science and engineering, but those that do—Guinea (42 percent), Burkina Faso (19 percent), and Chad (14 percent)—report apparently strong figures. However, these are essentially meaningless, as all report fewer than 1 percent of residents attending higher education. These figures are echoed throughout the region, making it certain, despite the lack of science and technology-specific statistics, that significant numbers of highly skilled science and technology workers are not being produced locally. One partially compensating bright light is the level of scholars visiting the United States. To be sure, figures show a wide range, with several states—Burkina Faso, Sudan, Chad, Guinea-Bissau, Ivory Coast, Mali, and Sierra Leone—having fewer than 30 visiting scholars per million residents, putting them in the lower half of the Islamic world. However others—Guinea, Senegal, and the Gambia—have over 30 each, comparable with Egypt, Kazakhstan, and Turkey, respectively.

Overall, Sub-Saharan Africa is in a different place from most other Islamic world regions. Output in industry

33 Communication from Bob Senseney, Department of State.

and academia is consistently weak, reflecting a poor state of education and low investment. The region's primary need at the moment is improved education, both in quality and, fundamentally, in scope. This is true at all levels, though the secondary level needs to be addressed most immediately. Again, this effort cannot be focused just on science and engineering—it must be part of an effort to increase quality and enrollment overall. At the same time, there are pockets of scientific strength—Senegal stands out—that can be drawn upon for collaboration. Amongst developing world regions, Africa also has one of the strongest sets of scientific networks (such as The New Partnership for Africa's Development (NEPAD),[34] University Science, Humanities and Engineering Partnerships in Africa (USHEPiA),[35] and the Association of African Universities[36]), which can be effective in harnessing region-wide capabilities and providing the ability, to some extent, to transcend the scientific limitations of the individual states. That these organizations are not limited to Muslim-majority states is not a problem; countries of the region share similar challenges, regardless of their religious makeup.

Europe and Asia Minor

Turkey, Azerbaijan, and Albania round out our survey. Albania averages 4 journal articles per million people, while Azerbaijan produces 9 per million, both similar to Central Asia; Turkey, in contrast, produces 40 articles per million people, similar to the stronger Middle Eastern states. Albania's output has been roughly constant, while Azerbaijan's decreased 21 percent per year from 1994 to 1999, and Turkey's increased 17 percent per year. For Azerbaijan (another post-Soviet state), this is the product of 2,800 scientists per million residents and spending 0.2 percent of GDP on research and development—very high numbers of scientists, resembling Central Asia far more than any other part of the Islamic world. Despite its much higher output, Turkey has only 300 researchers per million residents, though it spends 0.5 percent of its GDP on research and development. These figures for numbers of scientists and scientific output, taken together, suggest a much higher quality of research in Turkey (no detailed data exist for Albania).

Azerbaijan and Albania have very weak high-tech export sectors, with 0.4 percent of Azerbaijani merchandise exports high-tech, and 0.8 percent of Albanian merchandise exports in that category. High-tech comprises 3 percent of Turkey's exports, a much higher figure, and near the top end of the Middle East as well, but still low by international standards. Albania increases its share to 4 percent when medium-tech exports are included, but this is still very weak, exceeding only Sub-Saharan Africa; Turkey increases its share to 24 percent: 36th in the world, and very promising.

Neither Albania nor Azerbaijan participated in TIMMS; Turkey did, finishing ahead of Indonesia and Morocco and similarly to Iran and Jordan. Over 20 percent of Albanian and Turkish tertiary students studied science or engineering, but no data are available for Azerbaijan. Yet with only 15 percent of Albanians enrolling in tertiary education of any kind, and only 25 percent of Turkish residents enrolling similarly, this reasonable fraction of science and technology students does not translate into a sufficient output of science and technology-skilled graduates.

Turkey's international collaboration was dominated by the United States (30–49 percent of papers) and to a lesser extent by Germany (8–29 percent of papers). No data are available for Albania and Azerbaijan.

Albania and Azerbaijan, then, share most in common with Central Asia, and thus have similar needs. At least in Azerbaijan, there is no shortage of scientists—only

34 NEPAD, "Homepage," <http://www.nepad.org/>, accessed December 20, 2004.
35 USHEPiA, "Homepage," <http://web.uct.ac.za/misc/iapo/ushepia/middle.htm>, accessed December 20, 2004.
36 Association of African Universities, "Homepage," <http://www.aau.org/>, accessed December 20, 2004.

a mismatch of scientific skill with productive enterprise. Tertiary enrollment statistics for Albania suggest that it may not be as strong, meaning that improvements in tertiary education should be pursued. Both states need to increase the technology-intensive component of their exports, which, while perhaps not requiring more workers, may require retraining and will certainly require other broad adjustments. As in most other states, while a shift to high- and medium-tech industry will take a long time, there appear to be sufficient numbers of scientists for fruitful collaboration on immediate goals, especially when supplemented with outside expertise.

From the science and technology perspective, Turkey, though geographically close, is very different. In every measure bar the number of scientists, it significantly exceeds the other states in this region, often by a large factor; moreover, its performance has been trending in the right direction (if placed in the Middle East, it would be one of the stronger regional actors). Turkey's weakest point appears to be education, both in quality—TIMMS scores are low, though not compared to the rest of the Islamic world—and in quantity, with only a small fraction of residents seeking tertiary education. Given Turkey's success in research and industry, an effort to build the education base would appear promising. It is also worth noting that a crucial factor in Turkey's strong performance relative to the rest of the Islamic world is its membership of the North Atlantic Treaty Organisation (NATO) and its close association with the European Union. This means that Turkey has extensive collaboration with Western, developed countries. In particular, it receives funding from the European Union (through the European Union's Sixth Framework Programme of support for scientific research, and also from NATO. The evident benefits of these partnerships suggest that the application of similar programs to the wider Islamic world could bear much fruit.

Comparative Capabilities

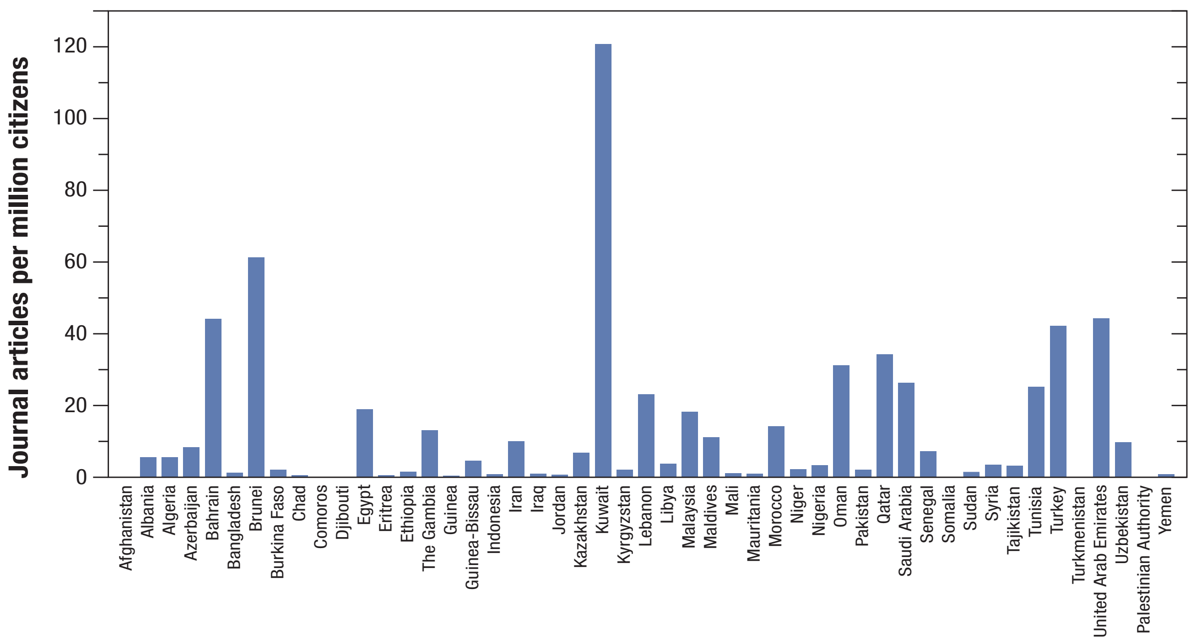
As one sweeps across the Islamic world, patterns and trends in science and technology performance emerge. In academic science and engineering, measured by journal publications per capita, the Middle East dominates, with 10 of the 12 top-performing countries hailing from the region (Turkey and Tunisia are the others). Extended to the whole world, the group of states with similar performance would include Brazil and Mexico, among others; its figures are too weak for it to include advanced states. The next tier is not geographically distinct: it includes Malaysia, Morocco, Iran, and three former Soviet Republics—Kazakhstan, Uzbekistan, and Azerbaijan. If extended to the whole world, it would include states like India and China. Below that, stronger sub-Saharan states such as Senegal, Nigeria, and Burkina Faso are accompanied by a variety of other states: Albania, Algeria, Libya, Tajikistan, Syria, Kyrgyzstan, and Pakistan. The bottom tier is occupied by weaker African states like Sudan and Mali, along with Bangladesh, Turkmenistan, Indonesia, and Yemen. If expanded, these last two groups would include many non-Muslim African states, Southeast Asian states, and Central American states.

Data on active researchers are too sparse to describe broad patterns. Still, one observation is important: the post-Soviet republics—those of Central Asia, and Azerbaijan—are consistently among the strongest. Azerbaijan and Uzbekistan have a level of researchers per capita similar to some lower-tier advanced states, like Spain and Italy. Kazakhstan, Kyrgyzstan, and Tajikistan have levels similar to Eastern Europe.

On the export front, Malaysia is on its own plane, with a level of technology-intensive (medium- and high-tech) manufacturing—65.1 percent—better than much of the advanced world. The next strongest group of Islamic world states, with levels roughly 3–5 times lower, comprises Turkey, Indonesia, Tunisia, and Morocco—these levels are similar to India, as well as to some advanced states such as Australia, and rank around 50th in the world. The next level is filled in by most of the Middle Eastern states, including Saudi Arabia, Jordan, and Egypt (accompanied by Pakistan), with exports comparable to less-than-stellar performers such as Honduras and Bolivia. The lowest level, including sub-Saharan Africa, Algeria, Yemen, Bangladesh, and most likely many states for which data are not available, is matched only by other states of sub-Saharan Africa.

On the education front, the TIMMS data are very thin, making it impossible to draw patterns. In general, Islamic world states show percentages of tertiary students in science and engineering similar to those in advanced states; the problem is often that few students pursue tertiary education in the first place. Few Islamic world states show similar higher-education enrollment levels to advanced western countries; Libya is the only state that is truly at a similar level, though Kyrgyzstan, Kazakhstan, Uzbekistan, and Egypt have similar levels to some Eastern European and stronger Latin American states (this may explain, in part, why these Central Asian states also have large numbers of researchers in science and engineering). The only other states with enrollments above the world average are Jordan, Qatar, Malaysia, and Turkey, all of which are close to the mean. A large number of Islamic world states fall just below, though, at a similar level to the weaker Latin American states: Azerbaijan, Tunisia, Saudi Arabia, Bahrain, Kuwait, Tajikistan, Iran, and Turkmenistan. Again, states in sub-Saharan Africa trail.

Figure 1 allows a comparison of the number of research journal articles produced per million residents throughout the Islamic world.[37]



37 Data for numbers of journal publications are from 2004 World Bank, "World Development Indicator."

Figure 2 shows the number of scientists and engineers per million residents, for those states for which data are available.[38] Note the relatively strong figures of the former Soviet states in Central Asia.

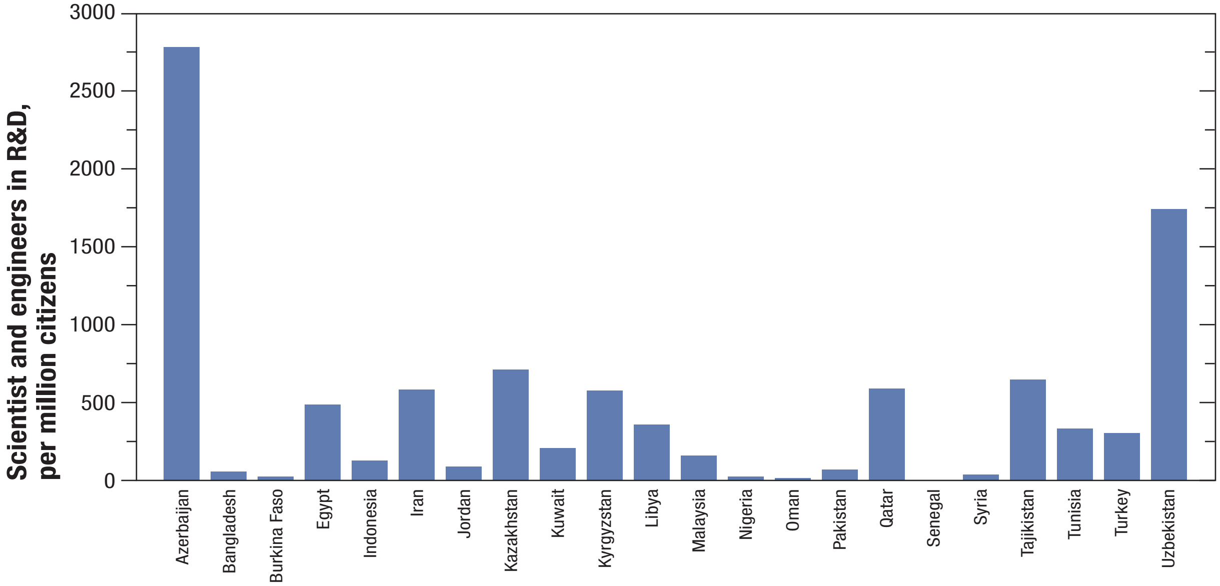
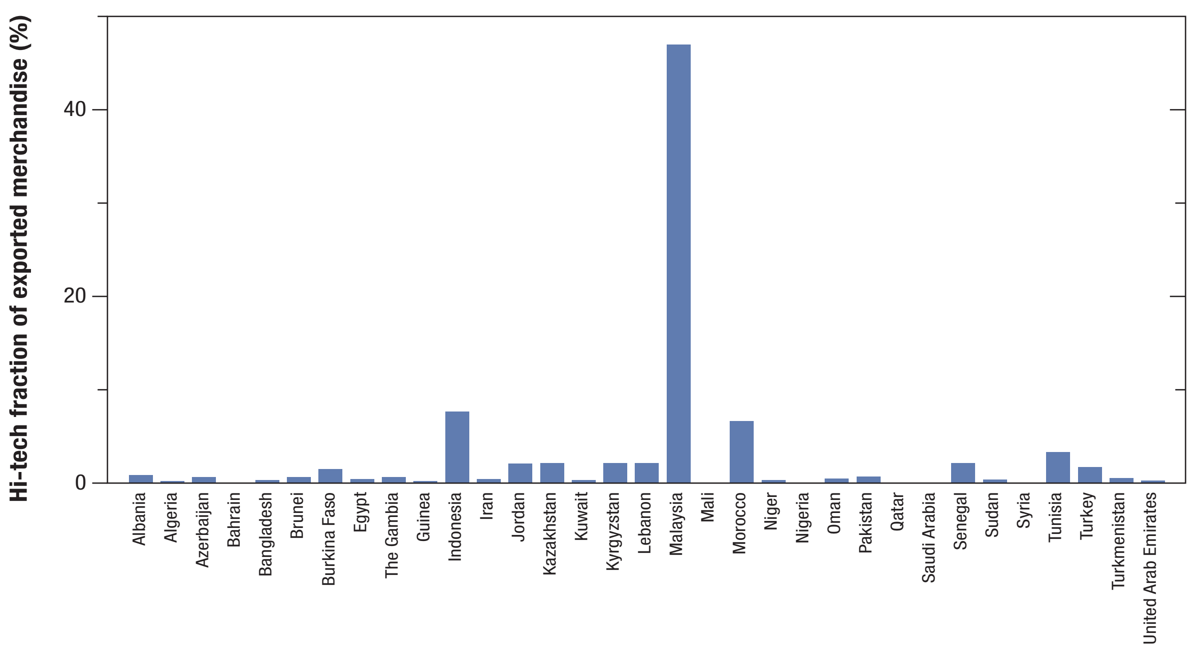
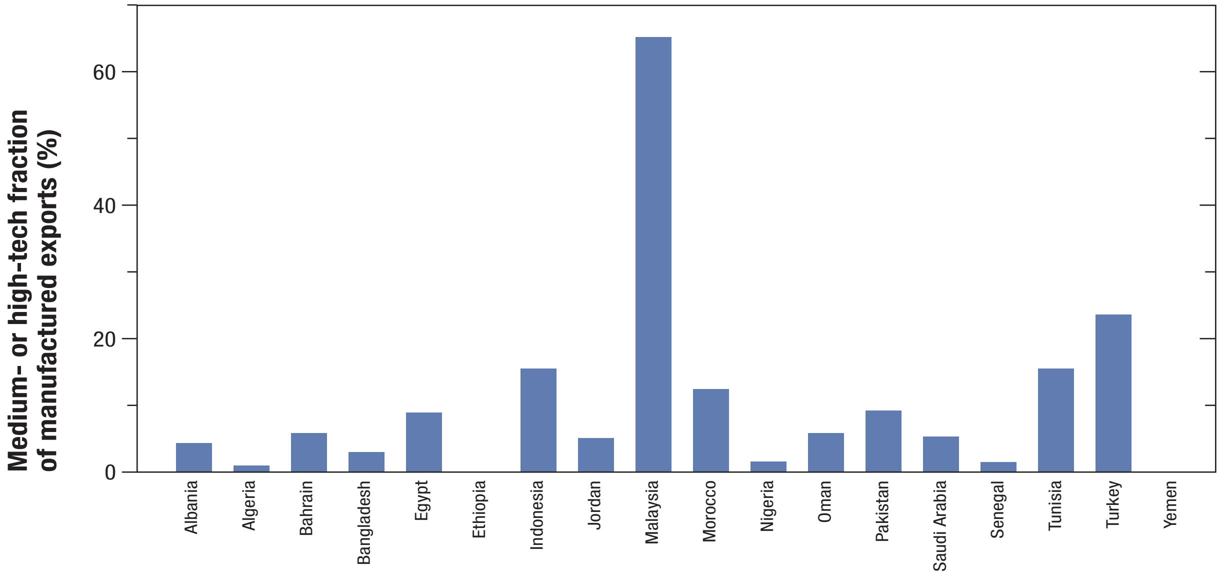


Figure 3 shows the fraction of exported merchandise that falls in the high-tech category.[39] With the exception of Malaysia, the figures are far lower than those typical of developed countries.



38 Data for numbers of scientists are from the "UNHDR 2003" 274–277, cross-checked with the 2004 World Bank, "World Development Indicator."
39 We use the 2004 World Bank, "World Development Indicator" to assess high-tech exports as of 2002 (or the most recent preceding year), expressed as a percentage of total merchandise exports.

Figure 4 shows the fraction of manufactured exports that fall in the categories of medium- or high-tech.[40] Again, Malaysia's performance dwarfs that of all other Islamic world states.



40 We use the UN Industrial Development Organization, "Industrial Development Report 2002/2003", 165–166, to assess combined medium–and high-tech exports, as of 1998, given as a percentage of total manufactured exports.

US Initiatives

We now turn to assessing the state of US cooperation with the Islamic world in science and technology. The bulk of US–Islamic world cooperation is conducted either by US government scientists and engineers or by private sector and academic scientists and engineers (often funded by the US government.) Though there is no overarching US government strategy for US–Islamic world science and technology cooperation—indeed, there is no articulated overall strategy for science and technology cooperation in general—there is still an impressive level of cooperative activity, ranging from science education to advanced research, and stretching across the Islamic world. In government, five key departments are involved: the Department of Commerce, the Department of Energy, the Department of Health and Human Services, the National Science Foundation, and the Department of State; other agencies involved at lower levels include the Environmental Protection Agency, the Department of Agriculture, and, to an even lesser extent, the US Bureau of Reclamation and the US Geological Survey. Several US government agencies with international science and technology activities, such as the Department of Transportation, are not active in the Islamic world at any significant level. Outside government, universities are the most prominent actors.

Since data on many Islamic world science and technology activities are sparse, in each discussion of a US government department below we focus on whatever part of the department's activities are most extensively disclosed. This leads to different approaches for the different sections, with some focusing on anecdotal reports and others on numbers of scientists and budget figures. In particular, many sections do not report comprehensive budget figures; programs involved often mix science and technology with other activities, and other programs are distributed geographically with no division of spending between Islamic world states and others reported (filling such data needs will prove a key building block to articulating an overall strategy). Following our discussion of US government programs, we review non-government activities, including universities, non-governmental organizations (NGOs), and corporations.

Department of Agriculture (USDA)

USDA international cooperation in science and technology occurs primarily through the Office of International Research Programs at the Agricultural Research Service (ARS), and through the Forest Service. Islamic world states directly involved in cooperative efforts with the ARS are Bangladesh, Jordan, Kazakhstan, Lebanon, Nigeria, Mauritania, the Palestinian Authority (West Bank/Gaza), Syria, and Uzbekistan; other states are involved through regional organizations[41] (it is unclear whether the Syrian cooperation has been halted in light of recently applied sanctions). Projects focus on irrigation, agricultural biotechnology, crop improvement and selection, human nutrition, pest control, and combating drug crops.

The USDA also enhances its effectiveness by working with established multilateral and regional bodies, most prominently the Consultative Group on International Agricultural Research and the Central Asia and the Caucasus Regional Program. It is unclear how much money the ARS spends on this research, but it is almost certainly a small fraction of that spent by other research bodies such as the National Science Foundation (NSF) and the National Institutes of Health (NIH).

The USDA Forest Service also has broad interactions across the Islamic world. In the Middle East, the Forest Service funds some of its own work, while also working on projects funded by the US Agency for International Development (USAID), in particular through the Middle-East Regional Cooperation Program (MERC) (see section on USAID for more details).[42] Partners include Jordan, the Palestinian Authority, Tunisia, Egypt, and Turkey, with projects addressing watershed issues, and sustainable land and water management. Cooperation on watershed management is also pursued with Albanian scientists.[43] In Asia, the Forest Service works with Indonesia on a broad Fire Management program.[44]

Department of Commerce

The National Institute of Standards and Technology (NIST), part of the Department of Commerce, has entered into scores of international cooperation agreements, including bilateral memoranda of understanding with Egypt, Indonesia, and Saudi Arabia, and multilateral memoranda of understanding with the Asia–Pacific Legal Metrology Forum (which includes Indonesia and Malaysia), and the Standardization and Metrology Organization for the Gulf Cooperation Council Countries.[45] In addition, during the 2001 fiscal year NIST hosted visiting researchers from Bangladesh (3), Egypt (17), Iran (3), Jordan (1), Malaysia (2), Morocco (4), Pakistan (1), Tunisia (1), and Turkey (6), a total of 38 individuals out of 609 foreign visitors; 2002 also saw researchers from Algeria, Lebanon, Nigeria, Tajikistan, Turkmenistan, and Uzbekistan.[46] Relative to the number of scientists in each country, the total number of 2001 visitors from Egypt, Turkey, Tunisia, Malaysia, and Bangladesh ranks them as well represented, comparable to South Korea and to Mexico, and, interestingly, much better represented than the typical developed country.[47] The others are much weaker, however, with rates of visitors from Pakistan, Iran, and Jordan similar to those for advanced states (advanced states will typically produce fewer visitors, relative to their total number of scientists, as they already have appropriate research facilities at home), and most countries in the Islamic world producing no visitors at all.

In addition to those researchers conducting research while at NIST, NIST also hosted foreign visitors for brief presentations. In 2001, their origins included Algeria (24), Egypt (20), Kazakhstan (3), Kyrgyzstan (2), Pakistan (1), Saudi Arabia (5), Tajikistan (1), Turkey (2),

41 Data in this section is drawn from ARS Office of International Research Programs, "Homepage," <http://www.ars.usda.gov/research/docs.htm?docid=1428>, accessed October 16, 2004.
42 USDA Forest Service, "INTERNATIONAL PROGRAMS: AROUND THE GLOBE: MIDDLE EAST," <http://www.fs.fed.us/global/globe/europe/mideast.htm>, accessed October 16, 2004.
43 USDA Forest Service, "INTERNATIONAL PROGRAMS: AROUND THE GLOBE: EUROPE: Albania," <http://www.fs.fed.us/global/globe/europe/albania.htm>, accessed October 16, 2004.
44 USDA Forest Service, "INTERNATIONAL PROGRAMS: AROUND THE GLOBE: ASIA: Indonesia," <http://www.fs.fed.us/global/globe/asia/indonesia.htm>, accessed October 16, 2004.
45 NIST, "International Agreements," <http://www.nist.gov/oiaa/intragre.htm>, accessed October 16, 2004.
46 S.F. Heller-Zeisler, ed., "Office of International and Academic Affairs, Activities Report for Fiscal Years 2001/2002" (Washington, DC: US Government Printing Office, 2004), 18. <http://www.nist.gov/oiaa/NISTIntlActivitiesFY01_02.pdf>, accessed October 16, 2004.
47 Numbers are adjusted by comparing total number of visitors to total number of researchers in the country. Not all states can be evaluated this way, as statistics on total numbers of researchers are not universally available.

Turkmenistan (1), and Uzbekistan (5), a total of 63 individuals from the Muslim world out of 953 visitors; 2002 also saw visitors from Albania, Bahrain, Bangladesh, Iran, Kuwait, Malaysia, Oman, the Palestinian Authority, UAE, and Yemen. The Egyptian number is high relative to other developing countries, but this is not so surprising since US–Egypt scientific cooperation is better developed due to the existence since 1995 of the US–Egypt Joint Science and Technology Fund.[48] The Algerian and Saudi totals would also appear to be high, relatively speaking, but no reliable data on the number of scientists in those countries are available. The other states listed averaged fewer visitors, relative to their scientific bases, than advanced countries. Most states are not even represented, though more states are involved in these brief visits than are involved in longer stays.

A significant fraction of the cooperative activities at NIST focused on standards, an important capability for states looking to produce and export more goods with technology-value-added. An extensive program of cooperation with Egypt addressed measurement capabilities, as well as research on materials and space systems. The agreement with the Standardization and Metrology Organization for the Gulf Cooperation Council Countries focuses on "documentary standards and conformity assessment."[49] In 2001, NIST representatives visited Algeria to discuss measurement technology for Algeria's oil and gas industry as part of the US–North Africa Economic Partnership. Beginning in 2002, the United States and Saudi Arabia entered into discussions about furthering their measurements cooperation, including training in physical metrology and building and fire code-related activities.

The National Oceanic and Atmospheric Administration (NOAA) is also an agency of the Department of Commerce and has a number of collaborations with research groups in Muslim majority states through its Office of Global Programs (OGP).[50] As part of the OGP's Africa Program, research in Ethiopia[51] (studying the effect of climate on the power industry), Mauritania[52] and Djibouti[53] (studying the use of climate information) has taken place. In the El Niño Southern Oscillation (ENSO) experiment, there is collaboration with groups in Bangladesh to study cholera there.[54] There is currently a project with groups in Burkina Faso to study climate forecasting in the Sudan–Sahel region.[55] Between 1992 and 2001, NOAA worked with Egyptian partners to develop and implement a River Forecast System for the High Aswan Dam.[56] Between 2001 and 2002, it worked (funded by USAID) with scientists in Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan to implement a snow forecasting system for an important Aral Sea tributary.[57] NOAA has also worked with Morocco to "encourage marine scientific exchanges and help establish a science-based fisheries management program similar to that of the United States."[58] NOAA also operates the Southeast and East Asia Regional Sea

48 Embassy of the United States, Egypt, "US Joint Science and Technology Fund," <http://www.usembassy.egnet.net/usegypt/joint-st.htm>, accessed November 16, 2004.
49 Heller-Zeisler, ed., 18.
50 NOAA OGP, "Homepage," <http://www.ogp.noaa.gov/>, accessed November 11, 2004.
51 NOAA OGP Programs, "Evaluation of Economic Contributions of Seasonal Climate Outlooks for Power Industry in Ethiopia," <http://www.ogp.noaa.gov/mpe/csi/esd/africa/fundproj/energy/babu.htm>, accessed November 11, 2004.
52 NOAA OGP Programs, "Awareness Raising and Planning Workshop for a National Strategy of Communication and Utilization of Climate Information in Rural Areas," <http://www.ogp.noaa.gov/mpe/csi/esd/africa/fundproj/commun/ahmed.htm>, accessed November 11, 2004.
53 NOAA OGP Programs, "Creating Awareness on the Use of Seasonal Climate Forecasts among the user communities in Djibouti," <http://www.ogp.noaa.gov/mpe/csi/esd/africa/fundproj/commun/nour.htm>, accessed November 11, 2004.
54 NOAA OGP Programs, "Enso Experiment Summary of Research Activities," <http://www.ogp.noaa.gov/mpe/csi/cvhh/expactiv.htm>, accessed November 11, 2004.
55 NOAA OGP Programs, "Pilot Studies to Evaluate Interpretation Methods, Intermediary Effectiveness, and Appropriate Levels of Intervention in the Provision of Climate Forecasts in the Sahel-Sudan: Climate Forecasting for Agricultural Resources Project-Phase 2," <http://www.ogp.noaa.gov/mpe/csi/econhd/2002/kirshen.htm>, accessed November 11, 2004.
56 National Weather Service: International Activities Office, "Status of Projects," <http://www.nws.noaa.gov/iao/iao_summaryOfProjects.php>, accessed October 16, 2004.
57 USAID, "Central Asia Republics Regional," <http://www.usaid.gov/pubs/bj2001/ee/car/>, accessed October 16, 2004.
58 NOAA Fisheries: Office of Science and Technology, "NMFS Cooperative Programs," <http://www.st.nmfs.gov/st3/bilateral.html>, accessed October 16, 2004.

Grant Network, which includes Malaysia and Indonesia, as well as the Indonesia Sea Partnership Program;[59] these programs foster research, education, and technology transfer. The International Research Institute for Climate Prediction,[60] established by a cooperative agreement between NOAA and Columbia University, has projects in Ethiopia, Eritrea, Niger, the Sahel, Pakistan, and Indonesia.

Department of Defense (DOD)

The DOD has a limited number of programs that involve technology transfer to, and scientific cooperation with, countries within the Islamic world.

The Defense Threat Reduction Agency (DTRA) operates programs to prevent the spread of and reduce the threat from weapons of mass destruction, and is therefore assisting a number of states of the former Soviet Union. In the Weapons of Mass Destruction Proliferation Prevention Initiative (WMD-PPI),[61] which aims to help non-Russian states of the former Soviet Union prevent the proliferation of WMD across their borders, the DTRA is working with Azerbaijan, Kazakhstan and Uzbekistan to "provide equipment and logistics support, training, and other support to those agencies of recipient governments vested with the authority to monitor borders for illegal transport of WMD or related materials." The Department of Defense will also install radiation monitoring equipment at ports of entry in Uzbekistan and provide related training; however, the US Department of Energy, not host-country technicians, will take responsibility for the long-term maintenance of this equipment.

The DTRA also pursues the Biological Weapons Proliferation Prevention-Former Soviet Union (BWPP-FSU) initiative,[62] active in Kazakhstan and Uzbekistan. It contains several components. The Cooperative Biological Research project aims to "increase transparency and encourage higher standards of conduct" by engaging "former biological weapons scientists in peaceful pursuits in order to prevent the proliferation of biological weapons expertise to terrorist groups and rogue states." The US contribution to this research is intensive, involving both military and civilian researchers.[63] The second component involves developing techniques for the detection of, and response to, threat agents. The third component, focusing on biosafety and biosecurity, strengthens the detection, storage and response networks for dangerous pathogens, minimizing the chance, and harmful potential, of an accidental or deliberate release of these pathogens.

These cooperative programs benefit both parties. The work of scientists with pathogen expertise in Kazakhstan, Uzbekistan, and the United States facilitates the monitoring of the pathogen stockpiles, and the prevention, detection, and treatment of any disease outbreaks. The United States contributes funding and expertise, while Kazakhstan and Uzbekistan contribute facilities and scientists, and all derive benefit in terms of new knowledge with which to tackle the threat of pathogens, as well as the employment of WMD scientists in non-weapons programs.

In 1998 and 1999, memoranda of understanding were signed between the US government and the government of Egypt concerning "basic principles for Scientist and Engineer Exchange and Mutual Cooperation in Research and Development, Procurement and Logistic Support of Defense Equipment."[64] In addition to promoting technology transfer and cooperation, the memorandum allows Egyptian sources to compete for procurement by the DOD.

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59 NOAA, "Sea Grant International Programs," <http://www.oarhq.noaa.gov/ia/Programs/sea_grant/seagrant.htm>, accessed November 10, 2004.
60 International Research Institute for Climate Prediction, "Homepage," <http://iri.ldeo.columbia.edu/>, accessed November 18, 2004.
61 DTRA, "Programs: WMD-PPI," <http://www.dtra.mil/Toolbox/Directorates/CTR/programs/wmdpp/index.cfm>, accessed January 22, 2005.
62 DTRA, "Programs: BWPP-FSU," <http://www.dtra.mil/toolbox/directorates/ctr/programs/bwpp/index.cfm>, accessed January 24, 2005.
63 Interview with Andrew Weber, Office of the Secretary of Defense, January 24, 2005.
64 American Chamber of Commerce in Egypt, "Partnerships and Agreements," <http://www.amcham-egypt.org/BSAC/ustrade/Partnership.asp#4>, accessed January 22, 2005.

In 2002 the US government and the government of Turkey signed a memorandum of understanding for Turkish partnership in the systems development and demonstration phase of the Joint Strike Fighter.[65] Turkey had already been a partner in the concept demonstration phase, enabling it to participate in capabilities modeling and simulation events. Through its involvement in the systems development and demonstration phase, Turkey will be able to develop industrial partnerships with US companies, benefit from technology transfer into the country and have preferential contracting arrangements with US companies such as Lockheed Martin, Pratt & Whitney, and General Electric.

The Air Force Research Laboratory conducts an Engineer and Scientist Exchange Program,[66] in which Egypt is a participant. The program provides the placement in the partner country, for one to two years, of DOD civilian and military scientists and engineers to participate in research and development activities. Likewise, scientists and engineers from the partner country undertake placements in the United States.

As well as managing military sales to foreign governments, the Defense Contract Management Agency (DCMA) governs the process by which US technology can, with approval, be transferred to foreign governments to allow hardware analogous to that of the US military to be produced abroad.[67] An example of this is the case where the United States gave permission for companies based in Turkey, which were 51 percent Turkish-owned, and all of whose workers were Turkish, to build F-16 fighters and their engines (the remainder of the companies was owned by General Electric and Lockheed-Martin). A subsequent order of F-16 fighters by Egypt was fulfilled using the Turkish-built planes. The United States is currently negotiating to establish the framework for comparable arrangements with other countries, including Egypt. Though these interactions are not primarily science and technology cooperation, they open opportunities for training of skilled technicians and for assimilation of advanced technology, which might be applied beyond the immediate defense projects.

Department of Energy (DOE)

Several DOE laboratories have been engaged in science and technology cooperation with institutions in the Islamic world. The activities split into two branches: those funded by the security-focused parts of the DOE, and those funded by the energy-focused components.

Since 1994 the National Nuclear Security Administration (NNSA) has operated the Initiatives for Proliferation Prevention,[68] which engage "former Soviet WMD scientists, engineers, and technicians to redirect their expertise to peaceful work through partnerships with US commercial enterprises." These scientists come from Kazakhstan, Uzbekistan, and other Central Asian states, as well as Russia and Ukraine. This program was allocated $23.2m of funding in Fiscal Year (FY) 2004 and has received a cumulative total of $166m from the US government; in addition, it has attracted $178m of funding from the US private sector. Apart from the obvious nonproliferation benefits, it has resulted in the completion of 100 projects, of which 22 have been commercialized, generating $24m of sales and other added value. The NNSA has also made cooperative agreements regarding the peaceful use of nuclear energy with a broad range of states, including a number from the Islamic world: Bangladesh, Egypt, Indonesia, Kazakhstan, and Morocco.[69]

The Office of Defense Nuclear Nonproliferation provides between $8m and $9m per year in funding to the

65 US Embassy, Ankara, Turkey, "DOD, Turkey Sign Joint Strike Fighter Agreement," <http://ankara.usembassy.gov/dod.htm>, accessed January 22, 2005.
66 Air Force Research Laboratory, "International Program Office," <http://www.rl.af.mil/div/IFB/program/programs.html>, accessed January 22, 2005.
67 Defense Contract Management Agency, "DSCA's Strategic Partnership with DCMA," <http://www.dcma.mil/communicator/archives/spring%20summer%202003/partnership.htm>, accessed January 23, 2005.
68 NNSA, "Initiatives for Proliferation Prevention," <http://www.nnsa.doe.gov/na-20/ipp.shtml>, accessed January 19, 2005.
69 NNSA, "Agreements for Cooperation in the Peaceful Uses of Nuclear Energy," <http://www.nnsa.doe.gov/na-20/cooperation.shtml>, accessed January 19, 2005.

National Laboratories and non-governmental organizations for regional security efforts in the Middle East, Central Asia, South Asia, and East Asia.[70] This money has funded work primarily at Sandia and Lawrence Livermore National Laboratory[71] (work with Los Alamos and Pacific Northwest National Laboratories, also funded by the same $8m–$9m, has been tightly focused on WMD matters, an area we do not discuss here).

Lawrence Livermore National Laboratory (LLNL) has engaged with partners in Central Asia, the Caucasus, the Middle East, and South Asia to collaboratively address security, seismic, hydrological, and environmental science and technology problems. The problems addressed are either common to most countries in the region or are transboundary in nature, strengthening the motivation for a regional, international approach to the projects.

In Central Asia, cooperation takes place, through the Science and Technology to Advance Regional Security in Central Asia (STARS) initiative,[72] in the assessment of seismic (earthquake) hazards, remediation of nuclear waste sites, and security for former biological weapons facilities.[73] In Kyrgyzstan and Tajikistan, there are projects to address the economic and environmental consequences of the Soviet uranium legacy; these improve existing conditions and "prepare for the possible intervention of an international donor."[74] An example of the latter is the World Bank's approval of a $6.9m project to secure uranium waste dumps at Mailuu-Suu in Kyrgyzstan.[75] In Kazakhstan, LLNL is working with the state-owned Kazatomprom[76] to improve the nonproliferation, economic, and environmental aspects of the nuclear fuel cycle, while in Uzbekistan it has formed a team with the Institute of Nuclear Physics and the State Customs Committee to install a pilot radiation portal monitor system at the four highest priority ports-of-entry. These systems could detect the smuggling of nuclear and radioactive material, and this initiative is being expanded to cover most other ports-of-entry. These collaborative efforts draw on Central Asia's large reserve of trained scientists; the scientists learn to use new equipment, which is then often donated to them for future work.

In the Middle East, work has focused on seismic assessments, hydrology (water quality and supply), and preparations for responding to radiological emergencies. The seismic work has entailed the sharing of technical information (including data from regional seismometers) between Israeli and Arab scientists, the establishing of new seismic stations, and the analysis of earthquake information. The hydrological work, which is also carried out collaboratively, has addressed both water quantity and water quality issues (which are critical to national security), and has included preparations for local commercialization of new technology. These bilateral and multilateral projects have transferred advanced computational techniques to better interpret field observations; they have also included an educational component for secondary, tertiary, and graduate students, as well as the general populace. LLNL has also been involved in assessing how best to engage with Libyan and Iraqi scientists.

In South Asia, work has focused on the cooperative exchange of seismic information and data; LLNL has formed an international team that includes Pakistan, India, and other regional countries.

70 Department of Energy, "FY 2005 Congressional Budget: Defense Nuclear Nonproliferation/Overview," (Washington, DC: Government Printing Office, 2004), 35–6, <http://www.mbe.doe.gov/budget/05budget/content/defnn/nn.pdf>, accessed October 16, 2004.

71 NNSA, "Regional Security," <http://www.nnsa.doe.gov/na-20/regional_security.shtml>, accessed October 16, 2004.

72 LLNL, "Laboratory Scientists to Offer Ways Science and Technology Collaboration Can Advance Regional Security in Central Asia," <http://www.llnl.gov/pao/news/news_releases/2002/NR-02-02-03.html>, accessed January 27, 2005.

73 *A Congressional Workshop on the Advancement of US National Security Through Science and Technology Cooperation in Central Asia*, LLNL, CD-ROM February 14, 2002.

74 Comments from Richard Knapp, LLNL, December 17, 2004.

75 Mines and Communities, "Kyrgyz Republic Funded to Secure Uranium Waste Dumps," <http://www.minesandcommunities.org/Action/press375.htm>, accessed January 19, 2005.

76 Kazatomprom, "Homepage," <http://www.kazatomprom.kz/eng/>, accessed January 26, 2005.

LLNL has also initiated plans for potential dialogues with science leaders in both Central Asia (through the Samarkand Dialogues) and the wider Muslim world (through the US–Islamic world Forum).

Sandia National Laboratory works with Islamic world partners primarily through its Cooperative Monitoring Center (CMC).[77] In addition to its primary efforts on WMD-related monitoring, the center pursues cooperative efforts on air, water, meteorological and seismic monitoring aimed at solving health and environmental problems. According to the CMC, "The methodology for projects is to develop cooperative scientific investigations of issues that are major concerns of these regional countries."[78]

Central Asian projects[79] at the CMC include transboundary river monitoring and cooperative epidemiology.[80][81] Though the transboundary river monitoring effort, NAVRUZ, is centrally a nuclear-related effort to check for radionuclides and other contaminants in the water—its participant scientists all hail from nuclear physics research institutes—it has important non-WMD-related dimensions that may provide lessons. The experiments monitor basic water quality parameters in shared rivers that "are crucial for domestic, agricultural and industrial use throughout Central Asia." Analysis of samples occurs both in the United States and in Kazakh and Uzbek laboratories. Sandia suggests that this cooperative effort can be "a precursor to cooperative, transboundary natural resource management." Again, these efforts address critical regional issues in a sustainable way, but are unlikely to be of direct benefit commercially.

In South Asia,[82] CMC work has focused on confidence-building measures related to the environment and infrastructure, including technical exchanges between South Asian states in the fields of seismology, energy security, and water resource issues (in addition to the efforts to counter WMD and arms proliferation).[83] The environmental work has focused on water resources, particularly through the South Asia Water Analysis Network,[84] part of the CMC's South Asia Transboundary Environmental Cooperation project. The Network comprises institutions from India, Pakistan, Bangladesh, and Nepal, and uses a cross-border approach to monitor water quality both in the border regions (India–Pakistan, India–Bangladesh, and India–Nepal) and in locations that will allow the effects of urban pollution and agricultural runoff to be better understood.

Work in the Middle East involving the CMC at Sandia[85] has largely taken the form of confidence-building measures (CBMs) of various types. These include the Radiation Measurement Cross Calibration project (in collaboration with the International Atomic Energy Agency (IAEA)), which improves and standardizes nuclear monitoring and measurement capabilities, and helps to create a network of experts for cooperative monitoring in the Middle East. Another CBM, in cooperation with Lawrence Livermore National Laboratory, increases the scientific and technological capacity of Middle East countries to deal with nuclear, chemical, and biological events, and improves the coordination between the countries. This will also help in preparations for oil spills, earthquakes, and accidental radiation releases. A project that is currently in the early stages will examine how technology can be applied to maritime CBMs, which

77 Details of the CMC's operations can be found at CMC, "Homepage," <http://www.cmc.sandia.gov>, accessed October 16, 2004.
78 Details are at CMC, "Homepage," <http://www.cmc.sandia.gov>, accessed October 16, 2004.
79 CMC, "Central Asia," <http://www.cmc.sandia.gov/regional-centralasia.htm>, accessed January 19, 2005.
80 CMC, "Central Asia Programs," <http://ironside.sandia.gov/Central/cmc_cap/cap.html>, accessed January 21, 2005.
81 Central Asia Monitoring Experiment for Nonproliferation, "Navruz: The Central Asia Transboundary River Monitoring Experiment," <http://ironside.sandia.gov/Central/centralasia.html>, accessed January 21, 2005.
82 CMC, "South Asia," <http://www.cmc.sandia.gov/regional-southasia.htm>, accessed January 19, 2005.
83 NNSA, "Regional Security," <http://www.nnsa.doe.gov/na-20/regional_security.shtml>, accessed January 21, 2005.
84 South Asia Environmental Monitoring Project, "Sawan: The South Asia Water Analysis Network," <http://sawan.icimod.org.np>, accessed October 16, 2004.
85 CMC, "Middle East," <http://www.cmc.sandia.gov/regional-middleeast.htm>, accessed January 19, 2005.

aid in ensuring the reliable flow of vessel traffic, especially in the Gulf region. There are also environmental CBMs, an example of which is the Sustainable Land Use project, commenced in 1999 and involving the United States, Israel, the Palestinian Authority, and now also Jordan, which collects meteorological and soil condition data.[86] (The management of this project is currently being transferred to the Cooperative Monitoring Center in Amman, Jordan (CMC@Amman) described below.)

The CMC has also been engaging Iraqi scientists, directing them towards peaceful pursuits, in a program[87] that complements both the Department of State's Iraqi International Center for Science and Industry and the Iraqi Nonproliferation Programs Foundation, established in June 2004 by the Coalition Provisional Authority (CPA) (see discussion in the section on Department of State activities). In contrast to the Department of State's efforts, the CMC project is open to scientists and technologists of all backgrounds, not just former WMD scientists. This three-phase project is enlightening for two reasons. First, as part of the work to reemploy former WMD scientists, it was concluded early on that a broader rebuilding of Iraqi science and technology would be necessary; that experience could provide lessons for developing science and technology in other states, independent of any WMD-related effort.[88] Second, the Iraq project was itself a collaborative effort with the UAE-based Arab Science and Technology Foundation, which may be a potential partner or facilitator for US-Islamic world cooperation. Phase one of the project, an initial survey of science and technology in Iraq and pilot projects in water and public health, has been completed. Phase two, to develop detailed project proposals and integrate Iraqi scientists into the international community, is underway. Phase three, in which funding for selected science and technology projects in Iraq and the initiation of research takes place, will commence in September 2005.

The CMC also hosts workshops for delegations from the countries with which it works, and its visiting scholars program[89] enables foreign experts, some of whom have been based in Bangladesh, Egypt, Jordan, Pakistan, the Palestinian Authority, and the UAE, to work with technical experts at the CMC to "explore how technology can support the development and implementation of security policy and agreements."

The case of the Middle East is somewhat distinct to those of the other regions, because in addition to the activities of the CMC at Sandia, there are initiatives implemented by the CMC@Amman,[90] established by the US and Jordanian governments in 2002. The CMC@Amman is modeled on the CMC at Sandia and, in addition to its explicitly security- and nonproliferation-related efforts, it focuses on public health, disseminating technology for cooperative monitoring purposes, resource management and environmental security, confidence-building measures in the region, and creating a forum for "multidisciplinary interactions among scientists, engineers, and policy-makers."[91] It will serve as the hub for the planned Middle East Consortium on Infectious Disease Surveillance,[92] which will work across national boundaries improve the region's monitoring of, and response to, a disease outbreak or biological attack. As part of the resource management and environmental aspect of its work, CMC@Amman is

86 CMC, "Cooperative Monitoring for Long-Term Sustainable Land Use in the Middle East," <http://www.cmc.sandia.gov/ILTER/>, accessed January 19, 2005.

87 NNSA, "NNSA Program to Engage Iraqi Scientists," <http://www.nnsa.doe.gov/docs/PR_NA-04-05_Iraqi_Scientists_program_(2-04).htm>, accessed November 18, 2004.

88 Interview with Alex Dehgan (former Special Advisor to the CPA for Nonproliferation), August 2004.

89 CMC, "Visiting Scholars Program," <http://www.cmc.sandia.gov/scholars-description.htm>, accessed January 19, 2005.

90 CMC—Amman, "Homepage," <http://www.cmc-amman.gov.jo/>, accessed January 19, 2005.

91 Arian Pregenzer and Amir Mohagheghi, "CMC Middle East Regional Security Program" (unpublished).

92 CMC—Amman, "Middle East Consortium on Infectious Disease Surveillance," <http://www.cmc-amman.gov.jo/pages/Epidemiology.htm>, accessed January 21, 2005.

cooperating with the US Department of Agriculture's Forest Service Inventory and Monitoring Institute on the Middle East Sustainable Arid Land Management Information Network.[93]

Outside the Office of Defense Nuclear Nonproliferation, the DOE has a Sister Labs program (LLNL, for example, has a sister lab in Morocco that does cooperative work on science and technology procedures and processes) and also engages in a small amount of energy-related cooperation. The DOE has bilateral cooperation agreements on energy initiatives with Bangladesh, Egypt, Kazakhstan, Morocco, Nigeria, Pakistan, the Palestinian Authority, Senegal, and Turkey.[94] This cooperation has typically been more explicitly policy-oriented than the Livermore and Sandia work, but it has had a distinct technical dimension.[95] For example, work with Senegal has helped scientists and policymakers there better understand renewable energy sources. Cooperation with Kazakhstan has involved remote sensing research, through the Agrarian Reform Support Project. In Pakistan, work has focused on environmental protection, with an emphasis on greenhouse gas reductions—a controversial priority for a developing state. Not all science and technology agreements have yielded science and technology cooperation; program officers report that the Bangladesh agreement, in particular, yielded no cooperative science and technology.[96] The DOE also has numerous multilateral energy agreements (agreements with more than two participants) but Turkey is the only Muslim-majority state to participate in such agreements.[97] In Turkey's case, the subjects of the agreements relate to energy conservation and fusion energy; other participating states in those agreements include Australia, Germany, Japan and the United Kingdom. The fact that almost no Muslim-majority states form part of the multilateral agreements may mean that this is an underused avenue for encouraging science and technology cooperation. It certainly indicates that the potential benefits of bilateral and multilateral agreements should be further studied.

Department of Health and Human Services (HHS)

The Department of Health and Human Services conducts, through the various components of the National Institutes of Health (NIH), extensive science and technology cooperation across the Islamic world. Several different vehicles have been used, including direct research grants to, and contracts with, foreign institutions, domestic grants with foreign components, and hosting of visiting researchers at the NIH. The most recent comprehensive data available on NIH international activities are for FY1999 (unless otherwise noted, observations below refer to the state of cooperation in that year).[98]

In FY1999, NIH hosted 81 visiting scientists from Islamic world states at a cost of $1.6m; this compared to a total of 2,954 visitors from the whole world at a cost of $70m.[99] Turkey was best represented, with 23 visitors, while Pakistan, with 10 visitors, ranked second. All regions, including Africa, the Middle East, South Asia, Southeast Asia, and Central Asia, were represented, though Central Asia was weakest with only one visitor (from Uzbekistan) involved.

The National Institute for Allergic and Infectious Diseases (NIAID) had the largest footprint in the

93 CMC—Amman, "The Middle East Sustainable Arid Land Management Information Network," <http://www.cmc-amman.gov.jo/pages/AridLandManagement.htm>, accessed January 21, 2005.

94 DOE, "International Agreements Country Search Page," <https://ostiweb.osti.gov/iaem/country-frame_bi.html>, accessed October 16, 2004.

95 Details of programs from George Person, DOE, e-mail communication, September 22, 2004.

96 DOE Office of Policy and International Affairs, "All in Force Bilateral Agreements," <http://www.doeal.gov/mocd/SandiaContractM202/Basic/AppJ_AgreementsInForce100103.doc>, accessed October 16, 2004.

97 DOE, "International Agreements Country Search Page," <https://ostiweb.osti.gov/iaem/country-frame.html>, accessed November 9, 2004.

98 NIH, "Fiscal Year 1999: National Institutes of Health Annual Report on International Activities," <http://www.fic.nih.gov/news/annrpt99.html>, accessed October 16, 2004.

99 NIH, "Fiscal Year 1999: National Institutes of Health Annual Report on International Activities," Chapter 1, <http://www.fic.nih.gov/news/annrpt99.html>, accessed October 16, 2004.

Islamic world. Countries involved in its work included Bangladesh, Burkina Faso, Egypt, Indonesia, Iran, Jordan, Lebanon, Malaysia, Mali, Morocco, Nigeria, Pakistan, Senegal, Sierra Leone, Sudan, Tajikistan, Tunisia, and Turkey.[100] Work primarily focused on research related to diseases endemic to the cooperating states; in most cases, with the exception of some studies of AIDS and certain exotic diseases now occurring in the United States (for example, West Nile Virus and Monkeypox[101]), the results would not have had immediate application in the United States,[102] though the longer-term benefits could be widely felt. A small fraction of the funding was used for more explicit training and education, as opposed to research, activities. Of note, activities in the Middle East and North Africa were mostly funded through the USAID Middle Eastern Regional Cooperation Program, which began in 1980 and promotes Arab–Israeli cooperation in, amongst many other things, research into vector-borne diseases.[103]

Cooperation between other NIH institutes and the Islamic world was different in two important ways. First, the collaboration was much more uneven—no other institute had relationships across the Islamic world, nor do relationships of all the other institutions even collectively cover nearly as much ground as NIAID's. Second, the collaborations more frequently addressed topics of direct concern to the United States, rather than restricting themselves to health issues of interest only to the partner country. Still, as the brief description below attests, collaboration with the Islamic world occurred in a large group of NIH institutes, and in several regions.

The National Institute on Aging collaborated only with Nigeria, comparing age-related dementia in the United States and Africa. The National Institute of Arthritis and Musculoskeletal and Skin Diseases collaborated with Turkish and Egyptian researchers on biotechnology-based topics. The National Cancer Institute (NCI) had broader relationships, through the Middle East Cancer Consortium, which includes Jordan, Egypt, and the Palestinian Authority, the US–Egypt Joint Science and Technology Fund, and a separate relationship with Turkey.[104] In 2003 the NCI organized workshops in Turkey and Jordan and hosted visiting scientists from Iran, Jordan, Nigeria, Turkey, Algeria, Bangladesh, Egypt, Ethiopia, Lebanon, Malaysia, Pakistan, and Syria. It also made a foreign research grant to Senegal to study prostate cancer, and undertook cooperative research programs with Egypt and Senegal.[105] The National Institute of Dental and Craniofacial Research worked with researchers from Jordan, Nigeria, Senegal, Sudan, and Turkey, on projects to study several oral diseases and disfigurements, as well as some work on HIV transmission.[106] The National Institute of Diabetes and Digestive and Kidney Disorders collaborates primarily with Turkish researchers, in addition to a small collaboration in Bangladesh;[107] the National Heart, Lung, and Blood Institute works with Egypt and Pakistan.[108] The National Center for Research Resources supports an international primate breeding center in

100 It is unclear whether native country researchers were involved in the collaboration with Burkina Faso, as the official counterpart was the World Health Organisation Onchocerciasis Control Program.
101 Remarks by Karl. A. Western at the Brookings Institution workshop, "Science and Technology Policy Towards the Islamic World," January 5, 2005.
102 NIH, "Fiscal Year 1999: National Institutes of Health Annual Report on International Activities," Chapter 6, <http://www.fic.nih.gov/news/annrpt99.html>, accessed October 16, 2004.
103 NIH, "Fiscal Year 1999: National Institutes of Health Annual Report on International Activities," Appendix B, <http://www.fic.nih.gov/news/annrpt99.html>, accessed October 16, 2004.
104 NIH, "John E. Fogarty International Center," <http://www.fic.nih.gov>, accessed October 16, 2004.
105 National Cancer Institute, "Office of International Affairs," <http://www.cancer.gov/aboutnci/oia/int-prog/page1>, accessed November 10, 2004.
106 NIH, "Fiscal Year 1999: National Institutes of Health Annual Report on International Activities," Chapter 11, <http://www.fic.nih.gov/news/annrpt99.html>, accessed October 16, 2004.
107 NIH, "Fiscal Year 1999: National Institutes of Health Annual Report on International Activities," Chapter 12, <http://www.fic.nih.gov/news/annrpt99.html>, accessed October 16, 2004.
108 NIH, "Fiscal Year 1999: National Institutes of Health Annual Report on International Activities," Chapter 17, <http://www.fic.nih.gov/news/annrpt99.html>, accessed October 16, 2004.

Indonesia[109] (the National Institute of Child Health and Human Development conducts extensive work in the Islamic world, but the researchers involved all appear to be Western, with the Islamic world involved only as a subject of study[110]).

Department of State

While the Department of State does not normally engage directly in science and technology cooperation with the Islamic world (or with anywhere else), it serves as an important facilitator for cooperative ventures. In some cases, its main involvement is in negotiating umbrella agreements to facilitate science and technology cooperation; in others, it actively brings together partners and funds activities.

Those states with which the United States pursues the greatest amount of cooperative science and technology have typically negotiated umbrella agreements governing cooperative work (this is most likely not a causal relationship; rather, states with greater scientific capacities and stronger political relationships with the United States are more likely both to enter into broad cooperation agreements and to pursue specific cooperative activities). These agreements are partly political and partly technical. Politically, they reinforce the commitments of both sides to cooperation, and can serve as rallying points to increase or cement funding for cooperative activities. As part of the process leading to entry into these agreements, the State Department will often survey the potential for cooperation with the candidate country, as it did recently in North Africa; combined with appropriate funding, this is a clear driver for cooperation.[111]

At the technical level, these agreements can ease normally mundane matters like travel, fund transfers, and equipment imports, which can be extremely burdensome in dealing with many Islamic world countries. They also incorporate agreements on intellectual property, legal liability, and export controls. A notable example of such an agreement is the US–Egypt Science and Technology Cooperative Agreement, first signed in 1995 and renewed in 2001, through which the cooperative programs under the auspices of NSF and USAID take place. The Joint Board that implements the agreement sponsors workshops organized jointly by American and Egyptian scientific and technical agencies, involving both the public and private sector, which promote information exchange. Partnership between US and Egyptian research and development (whether academic or industrial) is also fostered by the joint grants (of up to $60,000 for a 1–3 year period) available to research collaborators,[112] and the "Junior Scientist Development Visit Grants,"[113] which allow young Egyptian researchers (having received their doctorate within the past 10 years) to make a visit of up to six months' duration to a US institution. American PhD students, as well as those with a Masters, and postdoctoral scientists, can make research visits to Egypt. Since September 11, the United States has been rapidly increasing the number of its science and technology agreements with Islamic world states. Agreements with Tunisia, Bangladesh, and Pakistan have been entered into since 2003, and efforts to complete agreements with Algeria, Morocco, and Kazakhstan are in progress.[114] Notably, though the Department of State lists strengthening science and technology partnerships with Central Asia in general (along with Central America) as a key goal for 2005, it does not similarly cite the Middle East; as a lesser matter it does list improving the science and technology relationship with Jordan as a goal.

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109 NIH, "Fiscal Year 1999: National Institutes of Health Annual Report on International Activities," Chapter 24, <http://www.fic.nih.gov/news/annrpt99.html>, accessed October 16, 2004.

110 NIH, "Fiscal Year 1999: National Institutes of Health Annual Report on International Activities," Chapter 9, <http://www.fic.nih.gov/news/annrpt99.html>, accessed October 16, 2004.

111 Interview with Bob Senseney, Department of State, August 2004.

112 US Embassy, Cairo, "Joint Research Grants," <http://www.usembassy.egnet.net/usegypt/grants.htm>, accessed January 19, 2005.

113 US Embassy, Cairo, "Junior Scientist Development Visit Grants," <http://www.usembassy.egnet.net/usegypt/jrgrants.htm>, accessed January 19, 2005.

114 Department of State, "Strategic Goal 9: Social and Environmental Issues," <http://www.state.gov/m/rm/rls/perfplan/2005/html/29274.htm>, accessed October 16, 2004.

The Middle-East Partnership Initiative (MEPI), established in December 2002, supports economic, political, and educational reform efforts in the Middle East, linking Arab, US and global private sector businesses, non-governmental organizations, civil society elements, and governments. It is structured in four reform areas: economic, political, educational and advancement of women. To date, the administration has committed $129m to MEPI, in addition to the annual bilateral economic assistance to Middle East countries (over $1bn). MEPI is active in the following countries: Algeria, Bahrain, Egypt, Israel, Jordan, Kuwait, Lebanon, Morocco, Oman, the Palestinian Authority, Qatar, Saudi Arabia, Tunisia, UAE, and Yemen. The education pillar is the only one that has significant science and technology components, these being: the US–Middle East University Linkage Program, which strengthens university programs in different disciplines, including information and communications technology (ICT) and education, in a number of Arab countries (with funding of $1m in 2002, $1.2m in 2003); a drive to provide internet for Yemeni high schools ($1.5m in 2002); and the Jordan education initiative, which includes the expansion of broadband technology usage in the classroom ($4m in 2003).

Another Department of State program, in association with USAID, which fosters scientific collaboration is the US–Middle East University Partnerships Program,[115] established in 2003. The funding allocated for the 8 partnerships of this program was just under $800,000, which is not an insignificant help to each of the universities involved. The two technology-related partnerships center on ICT, and are between the University of Connecticut and Ain Shams University (Egypt), and Southern Methodist University and the Université de Tunis el Manar (Tunisia). The programs include efforts to improve both research and teaching, and in each case substantial additional funds are supplied by the participating US institution. Also in cooperation with USAID, the Department of State is assisting the latter's efforts to improve educational standards in Pakistan by the introduction of new textbooks to *madrassah* schools.

An indirect way in which the Department of State, with the direct involvement of US research institutions, is helping to develop science and technology capacity in the Middle East is through its involvement in the Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME) project.[116] This is a major resource for research in physics, biology and medicine (amongst other fields) and will be operated under the auspices of UNESCO. The Department of State's involvement is through its role in acting as an observer to UNESCO, and thus its presence (in an observing role) on the council of SESAME. The hardware for SESAME was donated by Germany as it was to be replaced there by a more advanced facility, and will itself be upgraded prior to operation in Jordan so as to ensure greater utility in the future. SESAME "aims to establish the Middle East's first major international research center as a cooperative venture by the scientists and governments of the region," and the 12 current members of the board are Bahrain, Egypt, Greece, Iran, Israel, Jordan, Morocco, Oman, Pakistan, the Palestinian Authority, Turkey, and the United Arab Emirates.

In January 2004 the Department of State initiated a program to establish the Iraqi International Center for Science and Industry, an institution similar in its purpose to the Science Centers in the former Soviet Union (see below). This two-year, $20m program to employ and re-train Iraqi scientists to work on reconstruction includes "science workshops, seminars, meetings between US program officials and former WMD experts, and a desalination project to tackle Iraq's water problems."[117] As of January 2005, preparatory work on this project, at a cost of $1.5m, had been

115 Department of State, "US-Middle East University Partnerships Program," <http://www.state.gov/p/nea/rls/30340.htm>, accessed November 16, 2004.
116 SESAME, "Homepage," <http://www.sesame.org.jo/index.aspx>, accessed December 30, 2004.
117 Christina Asquith, "A $20 million carrot to keep WMD scientists in Iraq," *Christian Science Monitor*, <http://www.csmonitor.com/2003/1222/p07s02-woiq.html>, accessed November 18, 2004.

undertaken and 120 Iraqi former WMD scientists were engaged.[118] In June 2004 the CPA established the Iraqi Nonproliferation Programs Foundation and endowed it with $37.5m to undertake similar efforts.[119] This program, however, is still pending, awaiting implementation.

Also in the context of nonproliferation, and as an exception to the general lack of direct Department of State involvement in science and technology cooperation, the Department's Bureau of Nonproliferation has undertaken an initiative to prevent the proliferation of expertise in weapons of mass destruction. This program "supports the engagement and permanent redirection of former weapon scientists worldwide,"[120] and its main focus has been on the countries of the former Soviet Union (FSU).

There are three components to the program. The first is "Science Centers,"[121] which has established the International Science and Technology Center in Moscow, Russia, and the Science and Technology Center in Ukraine based in Kiev, multilateral bodies to which the contributing countries include all members of the former Soviet Union, except the Baltic States and Turkmenistan. These centers fund a wide range of cooperative, civilian research projects and related training opportunities in a broad array of disciplines, including chemistry, physics, life sciences, and energy generation. The Department of State directly funds research projects in these Centers, and also provides the funds for research carried out there under the auspices of the US Departments of Agriculture and Health and Human Services, as well as the Environmental Protection Agency.[122] International collaboration is assisted through the Partners Program, which assists US private industry, scientific institutions, and other governmental or non-governmental organizations that wish to fund and collaborate in research and development. Institutes and companies from other Western countries are also collaborating with these Centers.

The second component of the program to prevent proliferation of WMD expertise is the "Bio-Chem Redirect program,"[123] which funds civilian research projects (in areas that include global public health, livestock and plant health, environmental monitoring and remediation, and measures to combat biological and chemical terrorism) in a number of FSU countries, including Kazakhstan and Uzbekistan. These projects engage former Soviet biological and chemical weapons scientists in collaborative research with US scientists.

The third component of the program is the BioIndustry Initiative,[124] which reconfigures former Soviet biological weapons research and production capacities for exclusively civilian use, and engages the associated scientists in collaborative research and development projects to "accelerate drug and vaccine development for highly infectious diseases." More recently, the Department has been seeking to re-direct Libyan and Iraqi weapons scientists into civilian research, but these efforts are at an earlier stage than those in the FSU, which have been in progress for over 10 years.

Environmental Protection Agency (EPA)

The EPA participates in bilateral research and development cooperation with several Islamic world states.[125] Its primary past cooperation has been with Sub-Saharan African states, conducted through regional institutions. It has conducted limited work with Central

118 Interview with Anne Harrington, Department of State, January 19, 2005.
119 See *Science* 304 (April 9, 2004):1884.
120 Department of State, "Nonproliferation of WMD Expertise," <http://www.state.gov/t/np/c12265.htm>, accessed December 30, 2004.
121 Department of State, "The Science Centers," <http://www.state.gov/t/np/pp/c8498.htm>, accessed December 30, 2004.
122 Interview with Andrew Weber, Office of the Secretary of Defense, January 24, 2005.
123 Department of State, "The US Bio-Chem Redirect Program," <http://www.state.gov/t/np/rls/fs/32398.htm>, accessed December 30, 2004.
124 Department of State, "BioIndustry Initiative," <http://www.state.gov/t/np/rls/fs/24242.htm>, accessed December 30, 2004.
125 This section is derived primarily from review of EPA's Office of International Affairs <http://www.epa.gov/oia>, accessed October 16, 2004.

Asia, in particular a regional greenhouse gas monitoring project in Kazakhstan, between 2000 and 2002, in partnership with KazNIIMOSK.[126] A new effort anticipates strengthening NGOs and environmental policymakers in Morocco through the building of relationships between, among others, technical experts.

Of special note is the "Middle East Environmental Security Initiative," a joint EPA/DOE effort. Together with Jordan, Israel, and the Palestinian Authority, it seeks to promote multinational technical cooperation amongst sometimes antagonistic partners.[127] It also promotes transfer of US technology.

National Science Foundation (NSF)

The NSF pursues a dedicated international cooperation program, administered by the Office of International Science and Engineering (OISE) in which Islamic world states participate. Its activities include fellowships, travel grants, summer institutes, workshops, and research projects.[128] Grants for collaboration may also be made by the NSF research directorates, sometimes jointly with OISE. These awards are made on the basis of scientific and educational merit,[129] not taking political or strategic considerations into account; NSF primarily funds the US side of the collaboration.

International programs in which NSF is a participant and sponsor include the Asia–Pacific Network for Global Change Research,[130] in which Bangladesh, Indonesia, Malaysia, and Pakistan are active, and the SysTem for Analysis, Research, and Training (START),[131] which facilitates research networks to study regional aspects of environmental change. START has active programs in or with Mali, Niger, Morocco, Senegal, Uzbekistan, Turkmenistan, Tajikistan, Kyrgyzstan, Kazakhstan, Indonesia, Malaysia, Bangladesh, and Pakistan. In addition, the NSF Pacific Earthquake Engineering Research Center sponsors, through its Lifelines Program, collaborative research with two Turkish institutions, Sakarya University and Middle East Technical University. Their work, in partnership with the University of California (UC), Berkeley, Brigham Young University, and UC, Los Angeles,[132] focuses on documenting instances of ground failure arising from the August 1999 earthquake in Kocaeli, Turkey[133] (the work is cosponsored by CALTRANS and Pacific Gas and Electric).

In 1995 the NSF, authorized by the US Congress, established the US Civilian Research and Development Foundation (CRDF),[134] a non-profit organization whose purpose is to promote international scientific and technical collaboration between the United States and states that have WMD-related scientific expertise (principally those in the former Soviet Union). It encourages scientists and engineers (particularly those formerly involved in weapons programs) in the partner states not to emigrate but to work on non-weapons research and development projects, and to move applied research to the market place for mutual US and partner state benefit. Grants in the past two years for collaborative projects have been made to groups in Azerbaijan, Kazakhstan, Kyrgyzstan, and Uzbekistan in fields ranging from geology, chemistry and physics to mathematics and information science. As well as its own initiatives, CRDF supports the US Departments of Defense and

126 EPA, "EPA Air Programs in Russia/NIS," <http://www.epa.gov/oia/airandclimate/byregion/russiaair.html>, accessed October 16, 2004.
127 Jewish Virtual Library, "The Environmental Security Initiative in the Middle East," <http://www.jewishvirtuallibrary.org/jsource/Environment/envtsec.html>, accessed October 16, 2004.
128 NSF, "Office of International Science and Engineering," <http://www.nsf.gov/home/int/>, accessed October 16, 2004.
129 Email from Elizabeth Lyons, NSF, January 23, 2005.
130 Asia–Pacific Network for Global Change Research, "Homepage," <http://www.apn.gr.jp/>, accessed November 11, 2004.
131 START, "Homepage," <http://www.start.org/>, accessed November 11, 2004.
132 UC, Berkeley, "Documenting Incidents of Ground Failure Resulting from the August 17, 1999 Kocaeli, Turkey Earthquake," <http://peer.berkeley.edu/turkey/adapazari/>, accessed October 16, 2004.
133 NSF, "International Dimensions of NSF Research & Education: Linkages to Research Programs for Other Countries," <http://www.nsf.gov/sbe/int/pubs/02overview/access.htm>, accessed October 16, 2004.
134 CRDF, "Homepage," <http://www.crdf.org>, accessed November 18, 2004.

State in the implementation of their programs that relate to these aims. In September 2004, CRDF brought a group of five Iraqi former WMD scientists to the United States to commence a dialogue with them and introduce them to US researchers.[135]

Beyond its specific programs, NSF has regional outreach efforts. The Africa, Near East, and South Asia program of OISE covers much of the Islamic world.[136] A review of all currently active NSF awards aimed specifically at Islamic world countries suggests the following observations (it is important to note that many awards involving Islamic world researchers are not part of this category, as they do not derive from funds earmarked for international cooperation. However, the numbers here are still suggestive of overall levels.) As of August 2004, there were 194 active explicitly cooperative projects with majority-Muslim states in North Africa, the Middle East, and South Asia with an expected total value of $5.5m, an average of $29,000 per grant.[137] This is a small fraction of NSF spending on international projects. For perspective, in FY2003 NSF requested $27m for its International Science and Engineering account;[138] the total amount spent in international ventures significantly exceeds that, just as Islamic world ventures exceed $5.5m, as both include efforts pursued using traditional accounts. Also, total figures for current grants should be compared to the NSF budget for several years, the duration of the grants. All told, less than 10 percent of international NSF spending likely goes to the Islamic world, indicating a possible gap of broader concern. States receiving funds are Algeria, Bangladesh, Egypt, Ethiopia, Iraq, Jordan, Kazakhstan, Lebanon, Morocco, Nigeria, Oman, Pakistan, Senegal, Tunisia, Turkey, and the UAE.

In Africa, work focuses first on building capacity, rather than on specific research results. It encourages the involvement of junior scientists, both from the United States and the African countries, and promotes work that benefits from Africa's unique biological, environmental, geological, anthropological, and cultural resources. Environmental science is the primary discipline supported by NSF; others include geological and biological science, materials research, global climate change, and natural resources management (the breakdown of these regional NSF efforts between Islamic and non-Islamic states is unclear). Materials research has benefited from the NSF-funded US–Africa Materials Institute, based at Princeton University.[139]

Only 8 joint projects explicitly aimed at cooperation with Muslim-majority states in Sub-Saharan Africa were in progress as of September 2004, three with Nigeria, three with Ethiopia and two with Senegal.[140] There is no strong pattern to the activities, though the NSF program officer responsible notes that, "collaboration in different areas depends on a number of factors: language, bureaucracy, and the specific attributes of each region," and that, "US and local scientists are using Africa as a laboratory for their studies, and this determines the type of research."[141] There is also an NSF grant for "Extending High Bandwidth Academic and Research Networking to Africa" to increase the internet bandwidth supplying African Universities, and to look at the infrastructure, regulatory environment, and other constraints.[142]

Cooperation with the Middle East, North Africa, and Asia Minor is dominated by work with Egypt and Turkey; the US partners in these collaborations are almost entirely academic institutions. In Turkey, the

135 Comments from Anne Harrington, Department of State, January 19, 2005.
136 NSF, "INT ANESA Program Homepage," <http://www.nsf.gov/sbe/int/anesa/start.htm>, accessed October 16, 2004.
137 This search was executed by looking for grants administered by Osman Shinaishin, who has responsibility for all Islamic states in these regions; simply looking at those programs explicitly categorized as cooperative research misses much of the activity.
138 NSF, "Summary of FY 2003 Budget Request to Congress—International Science," <http://www.nsf.gov/bfa/bud/fy2003/ses_ise.htm>, accessed November 6, 2004.
139 US-Africa Materials Institute, "Homepage," <http://usami.princeton.edu/>, accessed January 27, 2005.
140 Based on NSF search for programs managed by Elizabeth Lyons; see notes on Osman Shinaishin in footnote 137.
141 Interview with Elizabeth Lyons, NSF, November 17, 2004.
142 NSF, "SCI: Extending High Bandwidth Academic and Research Networking to Africa," http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0451384>, accessed November 17, 2004.

national funding body TUBITAK has built up sufficient technical strength that it conducts peer reviews of, and provides funding for, collaborations, about 25 of which are supported annually. The most commonly funded fields of study are materials science, electrical engineering and geological sciences. In Egypt, in contrast, the US–Egypt Joint Science and Technology Fund administers all activities (through the US Department of State). As with Africa, participation of junior researchers is strongly encouraged. About 15 small research awards, and several workshop awards, are made annually by NSF under the Joint Fund program; other NSF programs can make larger awards. In Egypt the fields most often supported by NSF include information technology, materials, manufacturing, geological sciences, and environmental sciences and engineering. In Algeria, Jordan, Lebanon, Morocco, Oman, Tunisia, and the UAE, NSF makes an average of two or three awards each year, chiefly in engineering sciences, environmental biology and geophysics. Among activities explicitly aimed at international cooperation, the most common area of investigation was materials science, which accounted for 57 projects with 7 partner states (all in the Middle East). Other notable fields are information systems (14 projects), agriculture (13 projects), water resources (13 projects), and software development (11 projects).

The South Asia effort has spurred collaboration with Pakistan and Bangladesh (as well as with India), and NSF works with the Ministry of Science and Technology in both countries. The NSF credits stronger support from national science ministries for improving collaboration in recent years. As in the case of Egypt, non-OISE research programs in the NSF also make larger grants. The main thrust of recent NSF-funded work in Bangladesh has been the country's geology and the sources and mechanisms for arsenic pollution of ground water. Efforts with Pakistan have encompassed research in geological sciences, materials sciences, physics, and water resources, as well as workshops in information technology and optical communications.

Aside from the CRDF activity, explicitly funded cooperation with Central Asia is minimal. An examination of all current NSF grants mentioning Central Asia discovered only two cooperative projects, both involving researchers in Kazakhstan, one concerning ecosystem modeling and the other archaeology.

Cooperation with majority-Muslim Southeast Asian states is stronger, but assessing funding explicitly targeted at cooperation does not give the full picture. Malaysia invests enough in science and technology that Malaysian scientists may be able to collaborate with the United States without NSF grants. The NSF does, nevertheless, support cooperative research projects, conferences and planning visits, many in the fields of ecology, biodiversity and taxonomy. In the Indonesian case, cooperation cannot be listed as an explicit goal since travel to Indonesia is not currently supported. This is due to a Department of State travel warning, in place since 2003.[143] Hence the NSF has made fewer recent awards for work in Indonesia. It has been commented, however, that "Indonesia was/is one of the key countries in East Asia for research cooperation in ecology, taxonomy…global change and ocean/coastal science."[144]

US Agency for International Development (USAID)

The work that USAID carries out is determined by the Agency's five priorities, which are: health (including the issues of HIV, nutrition, and population), energy and information technology, agriculture, natural resources management, and environmental policy (which includes water resources and global climate change).[145] In addressing these priorities, many USAID

143 Email from William Chang, NSF, August 27, 2004.
144 Email from Elizabeth Lyons, NSF, January 23, 2005
145 Remarks of Rosalyn Hobson, USAID, January 12, 2005.

initiatives draw on or build up local and regional science and technology capacity.[146] While past studies have not focused specifically on the Islamic world, a review of congressional budget justification documents shows that USAID has engaged in science and technology cooperation across the Islamic world.[147] USAID may also be more effective than other agencies at coupling science and technology cooperation to the broader policy reforms often needed to allow that cooperation to have maximum impact.[148] Furthermore, given that USAID projects can be initiated by either the headquarters in Washington, DC or the mission overseas, and are then planned in cooperation with the country hosting the mission, USAID is well placed to tailor its efforts to particular regional needs. The main caveat in looking at USAID activity is that much of the science and technology work is "cooperative" only in the loosest sense, in many cases not using host country scientific and technological skills. In what follows, we look at work in the past two years, and at future plans. Given the diverse range of projects, we consider USAID's activities (some of which are undertaken with NGO, academic, or private sector participation) on a sector-by-sector basis. The sectors considered are: ICT development, technology transfer, research, and education.

A high standard of ICT has become integral to modern business, industry, and research; thus ICT development is crucial for progress in building up capabilities in more advanced science and technology. ICT also underpins collaborative programs, as rapid communication is a prerequisite. USAID engages in ICT work across the Islamic world. Its Digital Freedom Initiative[149] is a joint program of the US Department of Commerce, Department of State, USAID, Freedom Corps, Peace Corps, and Small Business Administration, and operates in Senegal, Indonesia and Jordan, aiming to provide access to domestic and global markets through the use of ICT; it includes skills training. Part of this program involves partnerships between US businesses (such as Hewlett-Packard and Cisco Systems) and local firms. The USAID-funded DOT-COM Alliance[150] also promotes the use of information ICT in developing countries, across all sectors. The program is active in 51 different countries, including Algeria, Morocco, Tunisia, Egypt, Jordan, Lebanon, the Palestinian Authority, Yemen, Afghanistan, Bangladesh, and Indonesia. The Agency's small Leland Initiative on African Information Technology (IT)[151] entails not only equipment transfer, but also training that enhances the ability of institutions—explicitly including those involved in scientific research—to use new IT infrastructure.[152] Other bilateral ICT work is pursued in Jordan, Lebanon, and the Palestinian Authority. This has included the development of infrastructure, training, scholarship (a strong emphasis, at the undergraduate and graduate levels), and the creation of a hi-tech park in the Palestinian Authority. Morocco, Algeria, and Tunisia are part of the US–North Africa Economic Partnership,[153] and its work in those states has focused on developing the ICT sector, both technically and commercially.

Technology transfer activities are prominent across the Islamic world. Most Islamic world countries involved with USAID receive some sort of health assistance, usually involving professional training and often involving equipment transfer. For example, in Central Asia, efforts aimed at tackling regional HIV and tuberculosis problems include training and building of advanced laboratories. The Centers for Disease

146 Anny Wong and Irene Brahmakulam, "USAID and Science and Technology Capacity Building for Development," (Washington, DC: RAND, 2002).
147 USAID, "Congressional Budget Justification FY 2005," <http://www.usaid.gov/policy/budget/cbj2005/>, accessed October 16, 2004.
148 Anny Wong and Irene Brahmakulam, "USAID and Science and Technology Capacity Building for Development" (Washington, DC: RAND, 2002).
149 Digital Freedom Initiative, "Homepage," <http://www.dfi.gov>, accessed November 11, 2004.
150 DOT-COM Alliance, "Homepage," <http://www.dot-com-alliance.org/>, accessed November 11, 2004.
151 USAID, "Africa: Leland Initiative," <http://www.usaid.gov/locations/sub-saharan_africa/initiatives/leland.html>, accessed November 11, 2004.
152 USAID, "Data Sheet," <http://www.usaid.gov/policy/budget/cbj2005/afr/pdf/698-016.pdf>, accessed October 16, 2004.
153 See USAID, "Overview of Country ICT Programs in Asia and the Near East," <http://www.usaid.gov/locations/asia_near_east/sectors/ict/ict-countries.html>, accessed November 16, 2004.

Control is the prime agency involved in implementing these infectious disease programs.

Agriculture is another key area of technology transfer; the focus is on Africa. The Initiative to End Hunger in Africa (IEHA)[154] focuses on programs to improve the use of modern technology and increase agricultural productivity and income for small-scale farmers; in addition, the West Africa Regional Program (WARP)[155] serves 18 nations, including Burkina Faso, Chad, the Gambia, Guinea, Guinea-Bissau, Mali, Mauritania, Niger, Nigeria, Senegal, and Sierra Leone. IEHA funding also aims to scale up USAID support for technology research, development and transfer by cooperating with regionally-based entities such as the West African Council for Research and Development and the Sahel Institute. Other efforts focus on individual countries. For example, USAID pursues an "Agricultural Technology Transfer and Micro-Enterprise Development" program ($2.2m in FY2004, $2.1m in FY2005) in Ethiopia. To achieve its ends in Africa, USAID works with regional alliances of major technology developers, connecting them with NGOs, government research bodies, and the private sector.[156]

Other technology transfer initiatives address environmental and energy challenges. All the Muslim-majority Central Asian states were involved in water programs, including demonstration models for water efficiency,[157] irrigation systems,[158] and water data tracking and dissemination, the last item being pursued on both a bilateral and a region-wide basis.[159] In the energy sphere, USAID has worked in Albania to provide the Albanian National Energy Agency with energy planning software, and provided training; this has resulted in a new Albanian National Energy Strategy.[160] Kazakhstan has received technical assistance, training, and hardware for tracking information used in the oil and gas industries, and in implementing new models for building heating efficiency;[161] Kyrgyzstan receives assistance in reducing energy losses throughout that sector, again involving the training and provision of technology;[162] in Turkmenistan, USAID provided support to start a chapter of the US Society of Petroleum Engineers at Turkmen Polytechnic Institute, establishing a channel for continuing cooperation.[163]

There is a strong environmental technology transfer component to USAID's work in Indonesia, including introduction of "sound watershed management methodologies that incorporate vital environmental services. Particular emphasis will be placed on conserving forests and biodiversity."[164] (This work is facilitated by the US Department of the Interior.) Other environmental work includes orangutan habitat conservancy and dissemination of water safety technology at the local level. In the energy sector, USAID is providing targeted assistance in renewable energy development and in greenhouse gas reductions.[165] Indonesia also receives assistance as part of the US–Asia Environmental Partnership,[166] directed towards improvements in water management and energy savings. South Asian states have also received assistance in technology transfer, emphasizing technical assistance in energy

154 USAID, "Initiative to End Hunger in Africa," <http://www.usaid.gov/locations/sub-saharan_africa/initiatives/ieha.html>, accessed November 11, 2004.
155 USAID, "Africa: WARP Country Information," <http://www.usaid.gov/locations/sub-saharan_africa/countries/warp/>, accessed November 11, 2004.
156 USAID, "WARP," <http://www.usaid.gov/policy/budget/cbj2005/afr/pdf/warp_cbj_fy05.pdf>, accessed November 11, 2004.
157 USAID, "Kyrgyzstan," <http://www.usaid.gov/policy/budget/cbj2005/ee/pdf/kg_cbj_fy05.pdf>, 5, accessed November 11, 2004.
158 USAID, "Tajikistan," <http://www.usaid.gov/policy/budget/cbj2005/ee/pdf/tj_cbj_fy05.pdf>, 5, accessed November 11, 2004.
159 USAID, "Central Asian Republics Regional," <http://www.usaid.gov/policy/budget/cbj2005/ee/pdf/car_cbj_fy05.pdf>, 4, accessed November 11, 2004.
160 USAID, "Albania," <http://www.usaid.gov/policy/budget/cbj2005/ee/pdf/al_cbj_fy05.pdf>, 12, accessed November 11, 2004.
161 USAID, "Kazakhstan," <http://www.usaid.gov/policy/budget/cbj2005/ee/pdf/kz_cbj_fy05.pdf>, 5-6, accessed November 11, 2004.
162 USAID, "Kyrgyzstan," <http://www.usaid.gov/policy/budget/cbj2005/ee/pdf/kg_cbj_fy05.pdf>, 5, accessed November 11, 2004.
163 USAID, "Turkmenistan," <http://www.usaid.gov/policy/budget/cbj2005/ee/pdf/tx_cbj_fy05.pdf>, 5, accessed November 11, 2004.
164 USAID, "Indonesia," <http://www.usaid.gov/policy/budget/cbj2005/ane/pdf/indonesia_cbj_fy05.pdf>, 19, accessed November 11, 2004
165 USAID, "Indonesia," <http://www.usaid.gov/policy/budget/cbj2005/ane/pdf/indonesia_cbj_fy05.pdf>, 22, accessed November 11, 2004.
166 USAID, "Data Sheet," <http://www.usaid.gov/policy/budget/cbj2005/ane/pdf/498-009.pdf>, accessed November 11, 2004.

regulation. Finally, in Turkey, USAID's Economic Growth Bureau oversees a water resource management plan for the city of Istanbul, implemented by Mississippi State University.[167]

USAID-sponsored research is primarily in Africa, where it focuses on agriculture, and in the Middle East, where it is broader-based. In 2004, USAID supported agricultural research at regional centers in Africa, while at the same time enhancing the capacity of individual states to make use of that research.[168] Other African research support is targeted at innovation in health care delivery (not just for training providers in existing methods),[166] at crop and soil research in Mali, Nigeria, and Senegal, and at malaria investigations in Mali.[170] Still other scattered efforts exist, such as in Senegal, where the Earth Resources Orbiting Satellite Data Center has undertaken collaborative research on carbon sequestration with Senegal's Environment Monitoring Center and Agricultural Research Institute.

In the Middle East, two research efforts are most prominent. The Middle East Regional Cooperation Program (MERC),[171] which began in 1980, funds collaborative research projects involving Israel and its Arab neighbors: Egypt, Jordan, Morocco, the Palestinian Authority, Lebanon, and Tunisia. American research institutions may also be included, and the US National Academies are involved in assessing the merit of grant proposals. The MERC program funds research and technology development within the natural sciences and engineering; the research is intended to be applied to regional problems. Total MERC funding for a project's duration (usually 2 to 5 years) can be up to $3m. The second prominent effort is the US–Egypt Science and Technology Agreement,[172] the aim of which is to "strengthen the scientific and technological capabilities of both countries, promoting scientific and technological cooperation in areas of mutual benefit for peaceful purposes." Priority areas currently include biotechnology, energy, environment, IT, manufacturing technologies, and standards and metrology. This is being funded at $3m in FY2004 and $5.5m in FY2005.

Remaining research efforts are scattered. USAID has established 7 US–Palestinian university partnerships, four of which concentrate on water resources development.[173] Outside of Africa and the Middle East, Bangladesh appears to receive the most support for research. It receives support for development of alternative fuels to kerosene,[174] and "research on new [HIV] prevention approaches and strategies,"[175] as well as "work by the US Geological Survey on the feasibility of tapping deep aquifers underlying most of Bangladesh for arsenic free water, and the International Centre for Diarrhoeal Disease Research, Bangladesh for work on the epidemiology of arsenic. [USAID] will also support biotechnology research through the Agricultural Biotechnology Support Project, and the Program for Bio-safety Systems."[176] Other efforts include "centrally-funded activities [in Kyrgyzstan that] include some applied research in health."[177]

Education is the final key area of science and technology cooperation and, again, efforts extend across the

167 USAID, "Turkey," <http://www.usaid.gov/policy/budget/cbj2005/ee/pdf/tr_cbj_fy05.pdf>, 1, accessed November 11, 2004.
168 USAID, "Data Sheet," <http://www.usaid.gov/policy/budget/cbj2005/afr/pdf/698-015.pdf>, accessed October 16, 2004.
169 USAID, "Data Sheet," <http://www.usaid.gov/policy/budget/cbj2005/afr/pdf/698-019.pdf>, accessed October 16, 2004.
170 USAID, "Mali," <http://www.usaid.gov/policy/budget/cbj2005/afr/pdf/ml_cbj_fy05.pdf>, 2, accessed November 16, 2004.
171 USAID, "MERC Homepage," <http://www.usaid.gov/locations/asia_near_east/merc04.html>, accessed November 11, 2004.
172 US Embassy, Cairo, "US-Egypt Joint Science and Technology Fund," <http://www.usembassy.egnet.net/usegypt/joint-st.htm>, accessed November 10, 2004.
173 USAID West Bank and Gaza, "Higher Education and Training," <http://www.usaid.gov/wbg/program_education_activity_2.htm>, accessed November 17, 2004.
174 USAID, "Indonesia," <http://www.usaid.gov/policy/budget/cbj2005/ane/pdf/indonesia_cbj_fy05.pdf>, 23, accessed November 11, 2004.
175 USAID, "Bangladesh," <http://www.usaid.gov/policy/budget/cbj2005/ane/pdf/bangladesh_cbj_fy05.pdf>, 17, accessed November 11, 2004.
176 USAID, "Bangladesh," <http://www.usaid.gov/policy/budget/cbj2005/ane/pdf/bangladesh_cbj_fy05.pdf>, 2, accessed November 11, 2004.
177 USAID, "Kyrgyzstan,"<http://www.usaid.gov/policy/budget/cbj2005/ee/pdf/kg_cbj_fy05.pdf>, 2, accessed November 11, 2004.

Islamic world, and, exceptionally, USAID's education initiative transcends the Africa and Middle East–North Africa bureau (most USAID work is carried out on a region-by-region basis). In Africa, the Africa Education Initiative[178] supports the training of new teachers and provides more textbooks and scholarships for children throughout the region, including its Islamic states; this will inevitably involve math and science. In Morocco, computer training will be provided to school-leavers, in partnership with companies like Microsoft and Cisco Systems. USAID supports education efforts across the Middle East; some higher-education efforts were described earlier under research. In Iraq, USAID money supports basic education as part of rebuilding, and five grants, worth about $15m, have been made to American university consortia for US–Iraqi university partnerships that will focus on archaeology and environmental research and other aspects of higher education. Given the comprehensive nature of USAID's education efforts in Central Asia, one can assume that some portion must include science and technology-related work; specifically, Kyrgyzstan, Tajikistan, and Uzbekistan received some assistance in education—those segments that likely included science were curriculum development work and teacher training. Indonesia also receives assistance in teacher training, which likely includes some training for math and science teachers.[179] Finally, in Pakistan, the USAID budget includes some plans for teacher training and text book development, which likely include some math and science; most striking, however, is an item (FY2004) for "improving the teaching of math, science, and English as a second language."[180] In contrast with programs in other Islamic world states, it is specifically targeted at math and science. It should be noted that elements in Pakistan have opposed the introduction of modern textbooks to the *madrassahs;*[181] this is a hurdle that must be crossed using political and diplomatic tools.

Private Sector Activity

US multinational corporations perform small amounts of research and development in the Islamic world (such research and development is technically performed by the corporations' foreign affiliates). Data are sparse—in particular, when only a handful of companies is investing in a given country, information is often guarded as proprietary. In addition, it is difficult to assess the extent to which research and development by foreign affiliates is being performed by host country scientists or by American scientists stationed abroad. In either case, however, these activities suggest that the infrastructure may exist to employ properly trained host country scientists.

Relatively low foreign direct investment (FDI) is a sign that much progress is still needed. Speaking in June 2003, Alan P. Larson, the then US Under Secretary of State for Economic, Business, and Agricultural Affairs, commented, "In 2002, Turkey attracted less than $600m in FDI. This is on a par with Bolivia. Looked at differently, this is roughly 10 percent of FDI flows to Poland, 5 percent as much as Mexico, and 2 percent as much as Brazil."[182] However, when considering that part of FDI spent on research and development,[183] Turkey's situation seems much more hopeful. Turkey leads Islamic world countries as the recipient of US FDI for research and development, with $13m spent in 2002. This spending was dominated by $9m spent on chemicals manufacturing. Malaysia may receive more, but the totals spent by foreign affiliates in its dominant computer and electronics industry are not publicly disclosed. However, in 2002, according to PriceWaterhouseCoopers, multinational corporations invested $114m in 19 electronics-sector research and development projects in Malaysia, suggesting that US involvement may well have been

178 USAID, "AEI," <http://www.usaid.gov/locations/sub-saharan_africa/initiatives/aei.html>, accessed November 11, 2004.
179 USAID, "Indonesia," <http://www.usaid.gov/policy/budget/cbj2005/ane/pdf/indonesia_cbj_fy05.pdf>, 25, accessed November 11, 2004.
180 USAID, "Pakistan," <http://www.usaid.gov/policy/budget/cbj2005/ane/pdf/pakistan_cbj_fy05.pdf>, 4, accessed November 11, 2004.
181 Interview with Winston Yu, Department of State, January 7, 2005.
182 Alan P. Larson, remarks at Brookings Institution on June 26, 2003, <http://www.state.gov/e/rls/rm/2003/22028.htm>, accessed November 16, 2004.
183 Data derived from Bureau of Economic Analysis, "Comprehensive Financial and Operating Data, Preliminary 2002 Estimates, Table III.J.3," http://www.bea.gov/bea/ai/iidguide.htm#link12b, accessed November 20, 2004.

greater than in Turkey.[184] Among remaining Islamic world states, Egypt and Indonesia are the next strongest. Egypt received $5m in 2002, invested roughly equally in chemicals and machinery manufacturing. Indonesia received $3m in investment, concentrated in chemical manufacturing. These figures should be compared with US FDI in research and development in other states. Of the total US FDI for research and development worldwide in 2002, which was $21.2bn, Norway received $32m, Poland $31m, Thailand $22m, Hungary $19m and Greece $15m and member countries of the Organization of the Petroleum Exporting Countries (OPEC) $46m. Hence Turkey's position is quite comparable to that of its European neighbors, and Malaysia is similarly placed; Egypt and Indonesia lag somewhat (other states received far more money: the total invested in China in 2002 was $646m, and in South Korea $167m).

Other Islamic world states are, however, distant competitors. No African state receives more than $500,000 in US FDI for research and development, excluding research and development for mining industries, the totals for which are not disclosed. No Arab state other than Egypt hosts industrial research and development. Although precise data are not available, aggregate research and development investment in the Central Asian states, Pakistan, and Bangladesh totals less than $1m (and may be zero). The fact, and causes, of this paucity in scientific FDI in most of the Islamic world must be addressed. To be certain, not all Islamic world states have equal capacity to effectively absorb more science and technology-intensive FDI; nonetheless, many could.

A number of US defense companies have partnerships with companies in Islamic world states, to work on projects such as early warning systems, military vehicles and aircraft, information technology, radar, and missiles.[185] The majority of the collaborations are with companies in Turkey; others in Egypt and Saudi Arabia are also involved.

NGOs have also been active in science and technology in the Islamic world. The most active organization appears to be the National Academy of Sciences (NAS), which has been engaged in several initiatives. It has worked with academies of sciences in Islamic world states both through the Inter-Academy Panel on International Issues and, in some cases, bilaterally. It has spearheaded politically sensitive dialogue—for example, with Iran through its academy of sciences. It is also distinguished from other US organizations in that it takes a strategic view of science and technology cooperation with the Islamic world, rather than only thinking of countries or regions independently.[186]

The NAS was also involved in backing the new Iraqi National Academy of Science (INAS), which was launched at a meeting in London in November 2003[187] by Professor Hussain al-Shahristani. The INAS is also supported by the United Kingdom's Royal Society and the French Académie des Sciences, and is intended to play a role analogous to that of the western academies, "promoting pure and applied science for the service of the people and the country, and reviving Iraqi talents for the good of humanity," as stated in its charter. Currently there are efforts in the United States to create partnerships with the INAS, which does not yet have funding.[188] Furthermore, the London launch was sponsored by expatriate Iraqis, to the annoyance of their colleagues based in Iraq,[189] so there must be a settled understanding of the makeup of the INAS, and under which auspices it operates, before further progress can be made. Its remit, nevertheless, is wide and, once greater stability in Iraq is achieved, the INAS could offer opportunities for international collaboration and the advancement of science in Iraq.

184 Pearlene Cheong, "Malaysia," <http://www.pwc.com/extweb/frmclp11.nsf/DocID/0E82F6B85B1B6D0785256E85005493B8>, accessed October 16, 2004.
185 Defense Systems Daily, "US Defense Industry Global Partnerships," <http://defence-data.com/ripley/pagerip2.htm>, accessed January 23, 2005.
186 Interview with NAS official, August 2004.
187 The Royal Society, "Iraqi National Academy of Science is established," November 28, 2003, <http://www.royalsoc.ac.uk/news.asp?year=&id=1635>, accessed November 18, 2004.
188 Comments from William Sprigg, University of Arizona.
189 Remarks of Anne Harrington, Department of State, January 19, 2005.

Other organizations have been active in supporting science and technology in the Islamic world, too, though at a fairly low level. The American Association for the Advancement of Science (AAAS) stands out. It partnered LLNL in a 2002 conference on science and technology cooperation with Central Asia. The AAAS has a number of international programs to assist "international scientific cooperation, capacity-building and workforce enhancements, and sustainable development."[190] These are organized into several categories, including Sustainable Development, the Consortium of Affiliates for International Programs (CAIP), and the Women's International Science Collaboration Program. The Sustainable Development pillar has a component, to last five years, to protect biocultural diversity in the Niger Delta, Nigeria,[191] as part of which scientific research capacity in Nigeria will be developed and new partnerships created. CAIP is a multidisciplinary network of scientific and engineering societies formed in 1976[192] and encourages partnerships among the members, some of whom are located in Bangladesh, Indonesia, Kuwait, Morocco, Nigeria, Pakistan and Turkey. WISC awards grants of up to $4,000 or $5,000 to women scientists from the United States to plan new collaborations with colleagues all over the world, including almost every Muslim-majority state.[193] AAAS recently (October 2004) hosted a panel discussion on the role of science in the humanitarian crisis in Darfur, Sudan.[194]

Charitable foundations can also play a significant role in fostering development for science and technology. The Partnership for Higher Education in Africa,[195] originally dubbed the "Partnership to Strengthen African Universities,"[196] is a $100m program funded by four foundations: the Carnegie Corporation of New York, the Rockefeller Foundation, the Ford Foundation, and the John D. and Catherine T. MacArthur Foundation. It supports the improvement of higher education institutions in a number of sub-Saharan African countries, and the creation of higher-education networks, over the period 2000–2005. The four foundations already support work in Africa more generally. This joint program is currently active in only one Muslim-majority country, Nigeria. Examples of the activities it funds are assistance to libraries,[197] and improvements in ICT. Among the institutions that have benefited are Ahmadu Bello University, the University of Ibadan, the University of Jos, and Obafemi Owolowo University in Nigeria.

Sigma Xi, an international research organization,[198] has a program of international activities[199] that encourages scientific collaboration. In 1999, Sigma Xi received a grant from the David and Lucile Packard Foundation for a four-year program to promote interaction between scientists in developing countries and research colleagues around the world.[200] It has sought to expand access in the developing world to research information and journals, and to foster research networks and long-term collaboration. Of 18 countries to have received grants, Nigeria was the only Islamic world state. Sigma Xi also provides resources and information to facilitate possible international collaborations.

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190 AAAS, "Programs: International Activities," <http://www.aaas.org/programs/international/>, accessed November 18, 2004.
191 AAAS, "Niger River Delta Project," <http://www.aaas.org/international/ssd/nigerdelta/>, accessed November 18, 2004.
192 AAAS, "The Consortium of Affiliates for International Programs," <http://www.aaas.org/programs/international/caip/>, accessed November 18, 2004.
193 AAAS, "Women's International Science Collaboration Program," <http://www.aaas.org/programs/international/wisc/>, accessed November 18, 2004.
194 AAAS, "Darfur, Sudan: The Role of Science in a Humanitarian Crisis," October 20, 2004, <http://shr.aaas.org/darfur/>, accessed November 18, 2004.
195 The Partnership for Higher Education in Africa, "Homepage," <http://www.foundation-partnership.org>, accessed November 18, 2004.
196 Carnegie Corporation of New York, "Partnership to Strengthen African Universities," <http://www.carnegie.org/sub/program/partnership.html>, accessed November 17, 2004.
197 Sharita Forrest, "UI librarians working to rejuvenate African libraries," *New Bureau—University of Illinois at Urbana Champaign*, <http://www.news.uiuc.edu/ii/04/0422/Mortenson.html>, accessed November 17, 2004.
198 Sigma Xi: The Scientific Research Society, "About: Overview," <http://www.sigmaxi.org/about/overview/index.shtml>, accessed November 18, 2004.
199 Sigma Xi: The Scientific Research Society, "International Programs and Activities," <http://www.sigmaxi.org/programs/international/index.shtml>, accessed November 18, 2004.
200 Sigma Xi: The Scientific Research Society, "Packard International Science Networking Initiative," <http://www.sigmaxi.org/programs/international/packard.shtml>, accessed November 18, 2004.

The Leakey Foundation[201] supports science research into, and public understanding of, human origins. It has recently funded research taking place in a number of Islamic countries, including Ethiopia, Eritrea, Mali, Nigeria, Algeria, Egypt, Jordan, Syria, Turkey, and Indonesia. Although most grants are to foreign researchers based abroad, in some cases the grant is to a researcher of the same nationality as the country in which the research takes place, but who is himself based abroad (most often in the United States); this is still valuable for the science and technology development of the host country, as it fosters collaborative research.

Explicitly developmental efforts are also led by private sector corporations. The motivation can be both philanthropic and entrepreneurial, since development must lead to increased business and investment opportunities. As an example, Cisco Systems supports work to extend and improve internet connectivity,[202] as well as its collaboration with the US government projects detailed earlier. An aspect of this program has been the improvements to networks in Kabul, Afghanistan, in the wake of the war there, particularly for government buildings and the university. Cisco Systems also has a program to bridge the so-called "digital divide," i.e., "the gap between those who can effectively use new technology and communication tools, such as the Internet, and those who cannot."[203] A number of Islamic countries have been beneficiaries of the "Internet Training Centers Initiative" to provide training for and access to ICT.[204] These are Burkina Faso, Mali, Nigeria, Senegal, Egypt, Tunisia, Yemen, Bangladesh, Indonesia, Malaysia, the Maldives, Pakistan, Kyrgyzstan, and Turkey. There is also a "Less Developed Countries" program,[205] which aids Afghanistan, Bangladesh, the Maldives, Yemen, Burkina Faso, Chad, Djibouti, Eritrea, Ethiopia, Guinea, Mali, Mauritania, Senegal, and Niger. This program has focused on skills development in these countries, and has been performed in partnership with United Nations Development Program, the USAID Leland Initiative, the United Nations Volunteers, and the International Telecommunication Union.

In November 2004, Microsoft announced an alliance with UNESCO to increase access to ICT and ICT training in underdeveloped countries.[206] This will incorporate ICT training into the educational curriculum and prepare teachers for this work, develop networks to allow information sharing in education and other fields, develop technology and learning centers for young people in Arab North African states, and disseminate information to facilitate computer refurbishment, which will increase the accessibility of ICT. In addition to the North African states, numerous other Islamic countries could be expected to benefit from this initiative, though the specifics are not yet clear.

Universities and Third-Level Education

Through their training of students and researchers, American universities play a key role in improving the quality of science and engineering in the Islamic world. Detailed data are sparse—there are no country-by-country numbers for Islamic world science and engineering visitors, nor are there significant programs dedicated to hosting such visitors—but we can still estimate the scope of this activity. We focus on statistics for student visitors and exchange visitors to the United States.

201 The Leakey Foundation, "Homepage," <http://www.leakeyfoundation.org/>, accessed November 29, 2004.
202 Jane Butler, "Cisco's Connection to the Future," <http://www.carnet.hr/ceenet2002/program/ppt/butler.ppt>, accessed November 18, 2004.
203 Cisco Systems, "Digital Divide," <http://www.cisco.com/en/US/learning/netacad/digital_divide/index.html>, accessed November 18, 2004.
204 Cisco Systems, "Digital Divide: Program Overview," <http://www.cisco.com/en/US/learning/netacad/digital_divide/itu/overview/index.html>, accessed November 18, 2004.
205 Cisco Systems, "Digital Divide: Least Developed Countries Initiative," <http://www.cisco.com/en/US/learning/netacad/digital_divide/ldc/index.html>, accessed November 18, 2004.
206 Microsoft, "UNESCO MoU Virtual Pressroom," <http://www.microsoft.com/emea/pressCenter/unescomicrosoft/default.mspx>, accessed November 18, 2004.

The Institute for International Education (IIE) reports levels of foreign students for the 2000/01 academic year.[207] Though levels of visiting students from Islamic world states have dropped disproportionately since September 11, 2001, the statistics still give a good indicator of the relative levels of Islamic world visitors. The "Visiting Students" table on the right shows numbers of visiting students in absolute numbers and per million residents, ranked by the latter figure.

Notably, the average for the Islamic world, 61 visiting students per million residents, is of the same order, though still significantly smaller, than the world average of 91 visiting students per million residents. Only 12 Islamic world states are above that average, while 40 are below it.

Even with the pessimistic assumption that only 10 percent of Islamic world visitors study science and engineering, this would suggest a total of roughly 7,400 Islamic world science and engineering students, dwarfing the number of Islamic world scientists and engineers engaged directly by US government laboratories. A more generous estimate would assume 40 percent of Islamic world visitors in science and engineering—the same as the international visitor average—implying a total of 30,000 Islamic world science (including health) and engineering students in the United States.[208] The only other US engagement possibly approaching this scope, though without comparable depth, is the training of health professionals in the field.

Beyond students, the United States also hosts academic visitors. Though no organization appears to track directly the number of these visitors, we can estimate that number from immigration records. Exchange visitors normally travel on J-1 visas; therefore we

State	Total Visiting Students	Visiting Students per Million Residents
Kuwait	3,045	1603
UAE	2,659	985
Bahrain	562	937
Qatar	463	772
Lebanon	2,005	573
Jordan	2,187	465
Malaysia	7,795	353
Albania	1,118	339
Gambia	386	297
Oman	702	293
Saudi Arabia	5,273	254
Turkey	10,983	170
Brunei	25	83
Comoros	38	76
Senegal	732	75
Sierra Leone	336	73
Morocco	1,917	68
Palestinian Authority	237	66
Indonesia	11,625	57
Pakistan	6,948	49
Syria	713	47
Mali	439	43
Tunisia	385	41
Kazakhstan	540	36
Egypt	2,255	36
Eritrea	134	35
Kyrgyzstan	160	34
Azerbaijan	253	33
Bangladesh	4,114	32
Guinea	237	32
Iran	1,844	30
Mauritania	73	29
Nigeria	3,820	28
Yemen	411	25
Tajikistan	118	19
Ethiopia	1,205	18
Uzbekistan	418	17
Somalia	96	14
Turkmenistan	65	14
Djibouti	8	11
Sudan	366	11
Burkina Faso	112	10
Niger	87	9
Algeria	220	7
Iraq	155	7
Chad	51	7
Libya	39	7
Afghanistan	75	3
Total	73,876	61
World Total	**547,867**	**91**

207 Institute for International Education, "Foreign Students by Academic Level and Place of Origin, 2000/01," <http://opendoors.iienetwork.org/file_depot/0-10000000/0-10000/3390/folder/14677/OD2001ByCountryand+Level.xls>, accessed December 28, 2004.

208 IIE, "Open Doors: Fields of Study,"<http://opendoors.iienetwork.org/?p=31671>, accessed December 28, 2004.

State	Number of J-1 Entries	Number of J-1 Entries per Million Residents
Qatar	65	108
Jordan	494	105
Lebanon	341	97
Bahrain	49	82
Kyrgyzstan	327	70
Kazakhstan	959	64
Turkey	4051	63
Albania	193	58
Azerbaijan	419	54
Kuwait	79	42
Malaysia	713	32
Oman	64	27
Tajikistan	155	25
Uzbekistan	552	23
Turkmenistan	100	21
Tunisia	190	20
Senegal	167	17
UAE	42	16
Egypt	908	14
Morocco	379	13
Gambia	13	10
Chad	62	8
Saudi Arabia	173	8
Syria	127	8
Mali	53	5
Yemen	72	4
Sierra Leone	20	4
Pakistan	606	4
Algeria	116	4
Indonesia	746	4
Nigeria	481	4
Burkina Faso	38	3
Mauritania	8	3
Niger	31	3
Afghanistan	68	3
Eritrea	10	3
Guinea	16	2
Iraq	40	2
Iran	94	2
Ethiopia	95	1
Bangladesh	162	1
Sudan	4	0
Comoros	0	0
Libya	0	0
Total	13,116	10
World Total	**321,660**	**54**

examine the number of entries on such visas.[209] (Note that this will slightly overestimate the number of non-student entries, since some married graduate students travel on J-1 visas as well.) The table on the left shows the number of entries into the United States by exchange visitors, across the Islamic world, both in absolute numbers and per million residents, for 2003, ranked by the latter measure. Note that this is not the number of exchange visitors inside the United States, nor is it the number admitted to the United States in 2003—such statistics are not kept. Instead, it records the number of individual entries into the United States, counting each individual each time he or she enters (a visitor making many trips outside the United States would thus be registered many times, while a visitor remaining in the United States for the entire year would not be counted at all). As absolute indicators of the Islamic world academic presence, then, these data should be treated cautiously; as an indicator relative to the rest of the world, though, they should be reliable.

The world average is 54 entries per million residents, compared to the Islamic world average of 10; only 8 Islamic world states exceed the world average. As a lower bound on the number of exchange visitors, assume each enters the United States 5 times per year, and only 10 percent of them are in science and engineering; that would yield 260 visitors. More realistically, but still conservatively, if 25 percent of visitors were in science and engineering, and each traveled abroad twice per year, the above numbers would yield 1,650 visitors.

We also note that US government activity and support of Islamic world students and researchers at US universities are by no means separate. A large fraction of science at US universities is supported by the NSF and NIH, along with smaller amounts by other departments; this funding will often be used to support Islamic world students or visitors, though nothing in the NSF or NIH records will indicate that. In general, then, the level of student and exchange visitors likely

209 Office of Immigration Statistics, "2003 Yearbook of Immigration Statistics," (Washington, DC; Department of Homeland Security, September 2004), 93–96, 104–109, <http://uscis.gov/graphics/shared/aboutus/statistics/2003Yearbook.pdf>, accessed January 25, 2005.

reflects substantial NSF and NIH (in addition to corporate) funding that was not encompassed by the sections dedicated to those bodies.

Summary

The US government cooperates in science and technology in nearly every state of the Islamic world, stretching from Morocco to Indonesia and including surprising countries like Syria and Iran. Its work also spans the full range of sophistication, from pure to applied research through technology transfer and education. Though inconsistent, it touches on most parts of science, including physical and life sciences, health, and information technology. The dollar value of the effort is impossible to pin down, as much work is buried within larger programs, but total spending would appear to be of the order of many tens or a few hundreds of millions of dollars. This pales in comparison to total US spending on international science and technology, but is still significant in its own right.

In basic and applied research, the key bodies are the NSF, NIST, and NIH. The first two dominate work in the physical and pure life sciences, while the latter is the strongest body addressing health. All three add an important dimension to cooperation by promoting scientist exchange, and particular by bringing Islamic world scientists to the United States (this is how cooperation with scientists in states like Iran and Syria is legally possible, and responsible to pursue). Cooperation in research between these bodies and Islamic world scholars is uneven, and there are no general patterns that apply across all work. Other applied research is also performed by NOAA and by the USDA, though in both cases at much smaller scales.

Technology development and transfer is concentrated in USAID and DOE, with smaller contributions from NOAA, USDA, and NIST. USAID's science and technology work spans the Islamic world, though within that sphere its technology development and transfer work is dominated by Africa and by a handful of states in the Middle East (the exception is in health, where its efforts are more evenly spread). Although USAID has targeted more funds at the Islamic world, the science and technology focus of its Africa efforts does not appear to have spread. DOE also has extensive technology transfer efforts, focusing on Central Asia and on a handful of Middle Eastern states. NOAA and USDA's interaction with the Islamic world follows no strategic pattern, and involves transfer of, and training in, measurement and management technologies. NIST's contribution is of a different kind—it has attempted to train scientists and regulators in standards and measurement so as to facilitate other technology development. As such, it could be an important force-multiplier for other efforts. Private sector science and technology-related investment in the Islamic world is generally small, though some important philanthropic and entrepreneurial initiatives do exist. They offer a model for expansion of this type of effort.

On the education front, USAID dominates primary and secondary education, while NSF, NIST, and NIH are the most prominent government agencies in supporting post-secondary education (including continuing professional training). There are few USAID programs dedicated explicitly to science and technology, although some do exist; in general, we expect science and technology to be a part of USAID's broad education programs. NSF, NIST, and NIH contribute to education not through efforts in the Islamic world but by hosting graduate, postdoctoral, and mid-career scientists for short- and long-term visits, and, in the case of NSF and NIH, by funding US-based research in which students and visiting researchers from Muslim-majority countries participate. The presence of such scholars in US universities and institutions constitutes a hugely important interface between US science and technology and the Islamic world.

Towards a Strategy

The United States already benefits from its science and technology cooperation with the Islamic world, but to maximize the benefits of this cooperation—and to effectively expand it in the future—a coherent strategy is critical. With so many actors working with partners across the Islamic world, there is a wealth of experience to draw on. At the same time, a strategic view can ensure that resources are not focused too narrowly, or in unproductive programs. Most critically, in pursuing a strategy, it is important to keep in mind that the primary purpose is to advance the goals of American policy towards the Islamic world, not simply to advance science and technology. The latter, while a valuable goal, is of secondary strategic importance in this context.

Before tackling the broader strategic issues, some simple programming steps would provide a strong foundation for American efforts.

Programming Recommendations

Build an internal clearinghouse for US government-funded activities

The first requirement of any solid strategy is current knowledge of ongoing activity. No such repository of information on US–Islamic world scientific cooperation exists within the US government. This paper provides only a start in systematically and comprehensively amassing information on US activities; a new effort to track ongoing activities should be established, either in the State Department Bureau of Oceans, Environment, and Science, or the White House Office of Science and Technology Policy (OSTP).

The inconsistent and uneven record-keeping across the US government has not gone unnoticed, but past attempts to track cooperative science and technology efforts across the government have failed simply because the reporting burdens on the individual agencies have been too onerous. Any new effort will have to learn from those past failures. Any effort will also, on the one hand, have to be careful not to restrict itself to research and development while, on the other, not so expanding in its scope, in attempting to cover all science and technology, that it becomes overwhelming.

Depending on the purpose of the clearinghouse, the effort involved in maintaining it could be reduced. In particular, if the primary purpose of collecting information on US efforts were to underpin public diplomacy, skeletal information about overall programs, in addition to descriptions of some interesting projects, could be circulated. However, if the database became aimed primarily at accountability, the amount of information required—and thus the agencies' reporting requirements—could balloon.

It may be challenging for some departments to isolate the Islamic world components of their multinational efforts for reporting. In that case, the clearinghouse initiative might be expanded to all US government science and technology efforts. This, though, would greatly increase the work involved, since the Islamic world sees only a small fraction of international US science and technology. For this reason, and in view of the importance of developing US engagement specifically with the Islamic world, it would be desirable to limit the scope.

Conduct institution ssurveys in critical regions

One of the greatest barriers to US–Islamic world science and technology cooperation is the lack of US knowledge of potential partners for cooperation (this blind spot complements the lack of central knowledge of government-wide programming). A great deal of expertise is spread throughout the US government—at NSF, for example, a handful of individuals collectively have extensive knowledge of institutional strengths in basic and applied sciences throughout the Islamic world, while at NIH knowledge of institutional partners is spread throughout NIH's many constituent institutes. A government-wide, systematically organized clearinghouse would help agencies find partners for their efforts, and also avoid ineffective partners. It would also be used by outside institutions uncertain about potential partners. While the database's existence would be widely advertised, its content would have to be made available on a more controlled basis, since it might contain politically sensitive judgments of foreign institutions.

Given the current lack of a comprehensive effort, the US government has the best knowledge of, and thus the most confidence in, institutions in countries where its activities are already the most extensive. This serves to encourage further cooperation with a few select countries (Egypt, Turkey, etc.) while leading other states to stagnate. A deliberate effort to survey the Islamic world, much as the Department of State did for North Africa in 2003, would open new regions and disciplines to collaboration. Such knowledge could not be gained simply by assessing past cooperation.

Efforts should also be developed to expand the statistical data that are collected on science and technology capabilities within Muslim-majority state partners. These might best be accomplished through assistance to international surveys and through cooperation with local states and organizations. For example, expansion of the TIMSS surveys to more Muslim majority states would not only fill a data gap, but, in concert with other incentives, also potentially bolster reform in the education sector.

Expand the scope and consistency of training and exchange fellowships, while reviewing visa practices

The number of Islamic world students studying in the United States varies wildly from country to country. Though science and technology-specific statistics are not available, figures for overall levels of visitors are so varied that it would be unreasonable to assume uniformity for science and technology areas. As evidenced by figures for the number of visiting students per capita (see figures from IIE in table above), there is a wide disparity in the extent to which nationals of different Islamic world states benefit from study visits to the United States. Kuwait has roughly 1,600 student visitors per million residents, well above any other state. The UAE and Bahrain follow, with around 1,000, then come Qatar, Lebanon, Jordan, Malaysia, Albania, the Gambia, Oman, Saudi Arabia, and Turkey, which has 170 visitors per million residents. All other countries are below 100 per million residents, with no obvious differentiation between what might be termed strategic partners of the United States (such as Egypt) and others. Predictably, Libya, Iraq, and Afghanistan are among the least represented, the latter with only 3 visiting students per million citizens.

Though the reasons behind these levels cannot be firmly established, some inference is possible. Amongst those states with very high visitor levels, most are regarded as being of particular strategic value—Kuwait and Saudi Arabia for their key positions in the Persian Gulf region, Jordan because of its key 1990s role in the Middle East peace process, and

Turkey for its position as a bridge between Europe and Asia and because of its role during the Cold War (Malaysia should be seen as an anomaly: the high level of visitors is most likely due to the high standard of its scientists). This is not to say that strategic value has automatically translated into academic exchange, as evidenced by the low levels of visitors from Pakistan and Egypt.

To target academic exchange at areas of strategic value makes sense. Yet with terrorism as the strategic problem of the 21st century, that set of key states has changed, while exchange programming has not. Saudi Arabia is still critical, yet Pakistan is as important, if not more so. Jordan is important, for the same reason as before, but so is Yemen. The United States should actively seek to expand scientific exchange with the broader Islamic world, prioritizing it as necessary but not restricting it to a mere handful of states. To be sure, some states do not have the capacity even to provide qualified scientists for exchange, and the United States should not be hasty and draw in under-qualified scientists. Nevertheless, as scientific education at the lower levels improves in the Islamic world, the United States should actively seek to draw in students from across the Islamic world regions.

Any number of existing US government programs could be used to achieve this. Here, we note in particular the Fulbright Scholar Program's current Visiting Specialists Program[210] called "Direct Access to the Muslim World." This is administered by the Council for International Exchange of Scholars and provides opportunities for US academic institutions to host specialists from Muslim communities in the Middle East, North Africa, South Asia, and several countries in Central Asia, Southeast Asia, and Sub-Saharan Africa in order to "promote understanding of the Muslim World and civilization." This could also lead to the development of collaborative relationships. Currently science and technology disciplines are not eligible for this program; they would, however, be an important addition to it.

As the United States seeks to draw in Islamic world visitors, it will have to be mindful of the effect that new visa regulations have had on academic visitors, especially scientists, from the Islamic world. It is perfectly prudent to vigorously screen visitors as part of a homeland security effort, but the United States should be careful not to drive away too many qualified scientists as the result of that effort.[211] Such an outcome is inevitable if scientific exchange with the Islamic world is seen as expendable in the face of terrorism concerns. If, on the other hand, science and technology cooperation is a strategic tool, as we argue it should be, visa policies must be crafted with this in mind. As agencies and organizations develop their programs, they might build institutionalized nodes of connection with the Department of State and Department of Homeland Security to facilitate the visa process for invited guests. This will avoid the current embarrassment of one arm of the US government inviting in a Muslim visitor to bolster goodwill, while another denies them access.

Create a travel fund for workshops and conferences

Though advanced communications technology makes collaboration at a distance easier than it has ever been, personal contact is still critical. In particular, the bulk of successful collaborations between United States and developing world scientists have grown from personal relationships initiated at professional events, such as workshops and conferences.[212] Connections need not initially be deep—their critical contribution is to establish trust and, in some cases, to efficiently identify possibilities for collaboration.

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210 Fulbright Scholar Program, "Fulbright Visiting Specialists Program: Direct Access to the Muslim World," <http://www.cies.org/Visiting_Specialists/>, accessed November 17, 2004.

211 Fareed Zakaria, "Rejecting the next Bill Gates," *Newsweek*, November 29, 2004, <http://msnbc.msn.com/id/6542347/site/newsweek/>, accessed December 17, 2004, and Sam Dillon, "US Slips in Attracting the World's Best Students," *The New York Times*, December 21, 2004.

212 C. Wagner et al., "Science and Technology Collaboration: Building Capacity in Developing Countries?," RAND report MR-1357.0-WB, March 2001.

Current opportunities for such meetings are insufficient, a result primarily of most meetings being a substantial distance from Islamic world states, combined with a lack of funding for travel to distant events. The bulk of American funding goes to scientists already involved in collaborations, an important but incomplete approach. When money is made available for individuals not currently involved in collaboration, it is usually for very small, tightly focused workshops, placing a great, and often unreasonable burden on funding bodies to identify precisely which individuals should be tapped for which projects. Though the minimum cost will likely be higher, a future program that brings larger numbers of Islamic world scientists to more general scientific conferences will ultimately be more efficient and more effective.

A program of any useful scope will need to be funded by the federal government, but administration should be devolved, wherever possible, to the scientific societies. More specifically, it should be implemented by the societies that deal with individual areas of science, such as microbiology or physics. Those societies are closely and regularly involved in sponsoring and convening broad yet scientifically focused meetings. In contrast, the larger scientific bodies—the National Academy of Sciences or AAAS, for example—do not have the same level of involvement in field-focused meetings.

Some standard restrictions on travel funding should be relaxed. In particular, travel funding is normally given only to scientists presenting at a given conference. For the purposes of this program, however, that has the perverse effect of shutting out those scientists seeking to break into a field and who might be elevated through cooperation with US scientists. Emphasis should be placed on creating long-term and productive relationships with scientists and engineers, not just exchanging results from ongoing programs.

In addition to funds for Islamic world scientists, new funds should be made available for US scientists to travel to conferences and workshops in the Islamic world. These will not only broaden and deepen connections, but also actively demonstrate US respect for cooperation with the region as a two way street.

Strategy Recommendations

Focus first on science and technology, not research and development

Most Islamic world countries have limited use for basic research and development, even when commercially-oriented. In contrast to advanced developed countries, where research and development drive economic growth, experience has shown that states in the developing world—including the Islamic world—derive more benefit from learning and adapting foreign technology, then producing that type of goods, than from creating new technology. In contrast to a common perception in the Islamic world, this is not a route to dependency—the Asian Tigers began along this path but now conduct cutting-edge research. Most Islamic world countries have even less use for advanced non-industrial research. In states with critical immediate problems, research in fields that will see no applications for fifty years cannot be a priority, no matter how interesting the science. This appropriate prioritization must underlie American efforts to promote science and technology cooperation.

There are two important exceptions to the maxim that research should be accorded a lower priority. First, research that seeks to solve local or regional problems, such as the spread of certain diseases, which will not be pursued elsewhere due to its local nature, is worthwhile and indeed necessary. The second area of obvious benefit is when researchers pursuing abstruse work are also involved in high-quality teaching; such people also tend to act as academic role models, and can participate in a distinct way in the intellectual and political life of a country. The price to pay for retaining high-quality university teachers may be supporting their advanced research. That might not be too high a price to pay, especially for scholars in fields, such as mathematics and theoretical physics, that do not require expensive facilities.

All this being said, thinking in terms of science and, in particular, technology rather than research and development provides a powerful lens for judging and developing US efforts. It suggests, for example, that an effort should be directed as much at improving science and mathematics training in elementary schools as to enhancing university education. It also suggests that it is as important to bolster post-secondary technical vocational training as university education. It implies that funding that steers industrial research to basic adaptation may be much more effective than funding cutting-edge innovation.

Use science and technology cooperation as a tool to achieve policy changes carefully and sparingly

Full exploitation of improved science and technology capacity requires a host of public policies currently atypical of Islamic world states. Effective rule of law, universal education, openness to outside capital, macroeconomic stability, appropriate export orientation, and a sound intellectual property environment are all important factors in translating science and technology capacity to economic growth. This has led some to promote science and technology cooperation as a tool for inducing policy reform—given a new but not fully realized set of tools, a state might be more willing to break other barriers to progress.

However, the allure of science and technology cooperation is unlikely to regularly induce breakthroughs by itself. In many cases, the necessary reforms cut across society—for example, changes in macroeconomic policy have immediate and often harsh impacts on the poorer classes, and shifts towards universal education challenge deep-set cultural beliefs—meaning that far larger incentives, and often more time, are required to change them. The World Bank, for example, is able to affect macroeconomic policy through the massive loans it can offer; science and technology cooperation offers no incentives of a similar magnitude. Instead of trying to use science and technology to drive political change, it would be better to invest effort in harmonizing cooperative efforts with other attempts to affect policy. Science and technology cooperation should be viewed as an enabler of change, not a driving force on its own.

One possible exception stands out: intellectual property reform. The office of the US Trade Representative (USTR) classifies states according to their adherence to intellectual property standards (protection of patent, trademark, and copyright rights). In turn, when science and technology cooperation agreements are established with states, the level of data and information sharing permitted under the agreement is tied to the USTR's determination. Moreover, the agreements are often flexible, incorporating the prospect of changes should the state in question improve its intellectual property standing.

In some cases, state income may be so dependent on activities that violate American intellectual property standards (China is the leading example) that the prospect of science and technology cooperation is too small an incentive for change. In others, though, lax intellectual property laws may be more a consequence of neglect than of policy calculation. In these cases, the possibility of stronger science and technology cooperation (and the influx of money associated with that cooperation) may help prod states to improve their laws and regulations. Still, to the extent that their effectiveness can be undermined by broader failings in states' legal systems (poor enforcement, corruption), these improvements may be mostly superficial. Yet again, stronger levers will likely be required.

Take advantage of bilateral cooperation

In an effort aimed at reaching dozens of countries spread across the globe, there is a certain appeal in regional approaches, such as establishing international research centers or promoting intraregional cooperation. Indeed, such approaches have seen success in the past, with the Consultative Group on International Agricultural Research performing particularly well, effectively incorporating scientists from poorer countries in its work. This approach, however, faces imposing political barriers in much of the Islamic world. In two critical regions for American foreign policy—the Middle East and Central Asia—bilateral or limited multilateral approaches will generally be the most effective and expeditious for cooperation.

Each region poses problems for different reasons. In Central Asia, seventy years of central rule from Moscow have conditioned administrators to work through Moscow rather than directly with each other. While regional approaches are worth investigating, many are likely to get caught on this barrier; bilateral programs will often, though not always, be the best way to achieve short-term results. In the Middle East, a group of related problems arises around the competitive relationships between states in the region. In some cases, this is manifested as explicit conflict, as between Iraq, Iran, and their neighbors in the 1980s and 1990s. In most cases, the conflict is more one of egos, with no state wanting another to be the leader[213] (indeed, many states in the region would be happy to enter cooperative regional arrangements—as long as they are headquartered in or administered by them). Some suggest that the allure of science and technology cooperation could induce states into greater regional cooperation, but by all accounts the prospects are bleak; after so many failed attempts at broad Arab unity, science and technology cooperation is hardly likely to produce a breakthrough. Instead, a focus on bilateral cooperation, in addition to some sub-regional, task-specific efforts—for example, the NIST-GCC (Gulf Cooperation Council) cooperation on standards, and the MERC cooperation—would be more productive.

One point which is almost obvious but nevertheless deserves emphasis is that sufficient funding must be a critical component of a successful bilateral initiative. The US–Egypt Joint Science and Technology Fund,[214] which is a productive and successful bilateral collaboration, receives funding of $3m per annum, and this is important in making the joint projects possible. If the United States wishes to promote research in under-developed countries, whether Islamic or not, funding is essential, and therefore future bilateral agreements to develop science and technology should be granted adequate sums of money. Furthermore, the choice of recipients of US funding from agencies such as the NSF should reflect the strategic priorities of the United States, even if this means that less advanced countries receive more than the quality of their science alone would justify. This is important in order to maximize the benefit (not purely scientific) of US investment.

Regional approaches and networks can be powerful

Despite the political barriers to multilateral cooperation, such approaches can be very effective. In particular, multilateral approaches have worked in Africa where political barriers to cooperation were lower and where many small, poor states simply did not have the choice of working on their own. Though such approaches should not be taken at the expense of more reliable bilateral approaches, they are worth exploring.

Two types of specific arrangement stand out as candidates for future cooperation.[215] Regional centers of excellence have been established in chosen countries as magnets for elite regional scientists. At their best, such centers concentrate scientific skill, enabling fruitful collaboration and acting as nuclei from which other centers develop. US involvement in such centers might range from helping to establish arrangements (based on US experience) to involvement as collaborating researchers. The latter would help mitigate one potential pitfall—if there is not a critical mass of skilled researchers in a given field, a center set up for its pursuit may simply perpetuate bad science. The largest

213 Comments from Norman Neureiter, American Association for the Advancement of Science.

214 US Embassy, Cairo, "The Joint Science and Technology Funds," <http://www.usembassy.egnet.net/usegypt/joint-st.htm>, accessed November 16, 2004.

215 We do not discuss Islamic world-wide networks and arrangements here; in general, these suffer from a lack of shared needs and goals. Nonetheless, it may be worth exploring the utility of these organizations as partners in specific projects. These institutions include the Morocco-based Islamic Educational, Scientific and Cultural Organization (ISESCO), the Italy-based TWAS (the academy of sciences for the developing world), the Jordan-based Islamic Academy of Science (IAS), and the Pakistani-based OIC Standing Committee on Scientific and Technological Cooperation (COMSTECH).

downside to a center-of-excellence approach is political—in particular, many states may be happy to host a center, but be unwilling to participate in one that appears to belong to someone else; this danger is particularly acute in the Middle East.

Science and technology networks of cooperation and collaboration, connecting scientists and engineers with each other, break that political barrier. By not bringing scientists to the same place, they avoid choosing one country over its neighbors; though remote collaboration is not as effective, it can be supplemented by travel and temporary research visits. Again in Africa, the network model has been shown effective; an example of such a network (and established with funds from US charitable foundations) is USHEPiA,[216] based in South Africa and aimed at building institutional and human capacity in universities in sub-Saharan Africa. Currently no universities in Muslim majority countries are participants; even if none join in the future USHEPiA acts as a working model for an US–Islamic world counterpart.[217] Note also that there is no reason why collaborative networks should involve exclusively Islamic world countries. They will be more effective by linking countries with common interests and needs than by being based on a shared religious or even cultural identity. Furthermore, "ghettoizing" Islamic world states should be neither a goal nor an unintended side-effect of US government policies.

As ICT improvements spread throughout the Islamic world, the regional option will become more attractive. At the same time, that may allow greater involvement of US researchers in such networks, making it easier to pair US and Islamic world scientists for cooperation.

Involve the Islamic world diaspora

Many countries in the Islamic world have diasporas throughout the world, especially in the United States. These immigrant communities could be a very important asset in developing science and technology capability, as such groups are usually keen to retain and deepen their involvement in assisting their mother countries. The large Muslim American community (estimated between four to six million) thus can serve as a valuable potential bridge to the wider Islamic world in such efforts.

Two examples of successful partnership between the diaspora and colleagues in their homeland that might serve as models are provided by Ireland and Armenia. Ireland experienced severe emigration from the mid-19th century until the late 20th century, with the result that there is a large ethnic and expatriate Irish community in other English-speaking developed countries. A number of institutions funded by the science and technology-friendly Irish government, such as the Irish Council for Science, Technology and Innovation and Science Foundation Ireland, are now actively fostering academic and industrial partnerships between Irish abroad, especially in the United States, and their domestic counterparts. One example of such a partnership is BioLink USA,[218] which is an association made up of the members of Irish diaspora who are interested in promoting research in Ireland in the life-sciences.

The Armenian diaspora in the United States has been "an active participant in the economic and social life of Armenia,"[219] supporting the Armenian science and education sectors both through organizations such as the Armenian Engineers and Scientists of America and individually. Speaking in 2002, the Armenian Ambassador to the United States cited the American University of Armenia and the Center for the Advancement of Natural Discoveries using Light

216 USHEPiA, "Homepage," <http://web.uct.ac.za/misc/iapo/ushepia/>, accessed November 22, 2004.

217 Other organizations currently in operation include the New Partnership for Africa's Development, the UAE-based Arab Science and Technology Foundation (ASTF), the Association of African Universities, the Association of Arab Universities, and the Association of Arab Private Institutions for Higher Education. All but the ASTF should be considered a network.

218 Biolink, "Homepage," <http://www.biolinkusaireland.org>, accessed November 22, 2004.

219 Remarks of Dr. Arman Kirakossian, Armenian ambassador to the United States, September 4, 2002, see <http://www.armeniaemb.org/DiplomaticMission/Embassy%20Events/EmbassyEvents.htm>, accessed November 22, 2004.

Emission program,[220] a new synchrotron light source project in Armenia, as notable examples of the involvement of the Armenian diaspora in domestic science.

The lesson to be learnt as regards countries in the Islamic world is that using the skills, contacts and wealth of the diaspora to benefit science and technology in the mother country is feasible, with initiative from her government and goodwill on the part of the community abroad. Those members of the diaspora who are best placed to help are those who are themselves actively involved in science and technology, which places a certain requirement on their own levels of education and career advancement. Friendly relations between the governments of the country in which the diaspora resides and the home country are an important facilitator, as this can lead to binational entities through which the diaspora can work with scientists at home, as well as a favorable environment in which the outreach program from the mother country to the diaspora can flourish. The initiative will be, perhaps, most effective when members of the diaspora are themselves émigrés from the home country, but the US national experience shows that immigrant descendents retain an emotional attachment to their ancestral home that provides a foundation on which to build programs that develop science and technology there. The United States should explore further how to spur and facilitate such initiatives with partner governments in the region.

Coordinate science and technology cooperation with ICT improvements

Successful science and technology cooperation critically requires effective communication amongst participants. Thus, just as civil engineering would be unthinkable without good roads, so modern science and technology require a strong ICT backbone. Much of the work involved in establishing such infrastructure is not science and technology-cooperation per se, and hence we have not discussed it at length here. Nonetheless, businesses and aid agencies are extending ICT infrastructure throughout the developing world (USAID is the US leader), and science and technology cooperation would benefit from having those involved actively contribute to the efforts to install infrastructure. In particular, they should ensure that when connections are established in Islamic world countries, they connect universities as well as businesses; they might also consider providing software and training in scientific tools beyond standard business applications. US groups involved in establishing ICT infrastructure should also emphasize using local workers and providing them with technical skills, thus establishing an enduring science and technology capacity.

Cooperation could go even further, as in Hewlett-Packard's novel "E-inclusion" initiative.[221] This is less a philanthropic effort then a business initiative aimed at new and under-developed markets. Part of the goal is to close the gap between "technology-empowered and technology-excluded communities." The program involves forming partnerships with governments and private-sector firms, and enabling communications by means that are appropriate to a region's circumstances. These could include "solar-powered, satellite-connected kiosks and telecenters for villages; rugged, easy-to-use, low-cost appliances largely funded by the content that flows through them; and social adoption frameworks and business models that support the sustainable deployment and maintenance of such solutions." The business opportunities are envisaged to include selling products to be used in development programs (purchased, for example, by governments and NGOs) and developing new marketable products with regional partners, thus contributing to science and technology development in the region. Currently this program is not active in any Muslim majority country, but it is expanding and hence may be able to include such states in the future. The US government could promote the growth of such programs by disseminating

220 CANDLE, "Homepage," <http://www.candle.am>, accessed November 22, 2004.
221 HP e-inclusion, "Homepage," <http://www.hp.com/e-inclusion/en/index.html>, accessed November 18, 2004.

information about them, providing financial assistance and incentives to a company considering the investment, and encouraging the accommodation of the host country.

Promote cooperation that improves export capabilities

While science and technology cooperation is unlikely to stimulate major shifts in export orientation, it can help states that have already decided to improve their export stance. Specifically, the United States should support efforts to improve and increase manufactured exports with significant technological value added. Science and technology cooperation can have direct and relatively rapid impact in three areas: improved quality control and standards, improved ability to adapt and use licensed technology, and improved security on exports.

Adherence to standards, and the related matter of quality control, is critical to technology-driven export industries. There is no market for computer monitors with plugs that are not certified as compatible with international standards, nor is there much appetite for monitors that aim to conform with international standards, but which are regularly defective. Just as important as the ability to produce appropriate products is the ability to certify that they comply with international needs.

Cooperative science and technology may have trouble directly achieving short-term improvements in quality or ability to manufacture to standards, but it can have more explicit impact in helping to build the institutions that implement standards. NIST, the US government standards body, is already engaged in cooperation across the Islamic world, with some work on basic physics and other work on standards. Its work with the GCC countries is especially noteworthy, as it is working with regional scientists but also at the institutional level to develop strong standards institutions. The US government should consider expanding this effort to other Islamic world states with the potential to be technology-value-added exporters, on a bilateral basis if necessary. It should also consider involving scientists from US industry, where possible.

Security is also an important area for technical cooperation, since many tasks necessary to secure international trade require technological sophistication. For example, the United States is moving towards a system where sea-based shipments will have to be cleared as safe (for example, free of fissile materials) at their originating port. Confirming such safety often exploits technically advanced techniques like gamma radiography and gas chromatography; in turn, skilled operators are required to implement those techniques and to use the appropriate tools. Cooperative approaches to technical training can ensure that training in specific techniques leads to practices that fit well with existing local systems. In a leading example of such a scheme, the United States is looking at training Moroccan workers in technologically sophisticated port security techniques. There are other possible spin-offs for security cooperation, especially in communication skills and technology, and in data management infrastructure.

The third area with strong potential—adapting and using licensed technologies—is harder to address directly. It is most likely to be addressed through technology-intensive FDI that employs skilled local workers, rather than through government programs. The most that government programs can do is to help states to create an environment conducive to FDI, which can supply skilled scientists and engineers. The government could also establish an office to supply information and assistance to companies that might be interested in investing in Islamic world states. This would certainly allow the companies to do so with a greater degree of confidence, and would allow the government to guide investment to where it might be most beneficial and fruitful.

Develop a coordinated public diplomacy strategy for science and technology cooperation

As argued earlier, residents of the Islamic world generally hold American science and technology in high regard,[222] and are eager to emulate it. We have also demonstrated that the United States—and the US government in particular—pursues a large portfolio of science and technology cooperation with the Islamic world (and we have argued for its expansion). These should be the ingredients for effective public diplomacy—that is, promotion of the US image in the Islamic world through a demonstration of its goodwill and cooperation (actively dispelling the conspiracy theories espoused by terrorists and their supporters). Nonetheless, such an outcome is not automatic, as can be seen today. A deliberate public diplomacy effort that is integrated with and seeks to leverage science and technology cooperation is needed.[223]

Such an effort could be pursued at two levels. Embassies in individual states could publicly promote science and technology cooperation with the countries in which they are stationed. Staff would already have a good knowledge of any activities involving travel of US researchers to the country involved, or the transfer of equipment to the country. They might not, however, have ready access to information on long-distance collaboration, exchanges, and participation in multinational initiatives. Still, given its simplicity, an embassy-by-embassy approach would be a good start. Ideally, a broader effort would build on the information clearinghouse recommended above. This could both support officers at individual embassies and possibly underpin regional or Islamic world-wide campaigns. As an overall strategy is developed and expanded initiatives towards the Muslim world are built up across agencies, they should be coordinated with the Under Secretary of State for Public Diplomacy and Public Affairs, so as to ensure optimal effectiveness and coherence.

Develop an arms control strategy emphasizing capabilities, not just physical goods and export controls

Any strategy that seeks to improve science and technology capacity in the Islamic world must grapple with the strong competing interest of trying to deny any expanded ability to build advanced weaponry, in particular weapons of mass destruction.

To understand the depth of the problem, consider the case of Scomi Precision Manufacturing in Malaysia. A seemingly innocuous business, Scomi used sophisticated but not revolutionary machinery to produce specialized components for industrial processes. Unbeknownst to most of the world, for two years it applied those skills (as part of the Pakistan-based A.Q. Khan ring) to produce parts for gas centrifuge uranium enrichment, the critical and most demanding link in any nuclear weapons program. Most striking, Scomi did not employ parts that would have been targeted under export controls. Its ability was a simple byproduct of a state gaining technological capacity, aided by lax regulation of its specific activities. Traditional thinking about export controls is therefore insufficient for this complex task; a separate study is needed to address this part of the challenge, with or without an increase in US–Islamic world science and technology cooperation, though even more with it. Nonetheless, a few observations are appropriate.

While inadequate alone, traditional export controls are still essential. Umbrella agreements for science and technology cooperation have always incorporated export control restrictions, and should continue to do so. There is likely to be pressure to relax such controls for specific projects, particularly in the area of biotechnology, but exceptions are unlikely to be appropriate. If relaxed controls are prudent in one instance, they should be prudent to implement all across the export control system.

In deciding how to remedy problems posed by export controls, the purpose of the collaborative science and technology project in question is critical. Unless the

222 Zogby International, "Impressions of America 2004," (Washington, DC: Zogby International, 2004).
223 See also Government Accountability Office report GAO-03-951, "US Public Diplomacy—State Department Expands Efforts but Faces Significant Challenges," September 2003,<http://www.gao.gov/new.items/d03951.pdf>, accessed December 21, 2004.

goal is to produce an autonomous scientific or technological capability, work with controlled equipment can often be done in the United States or with equipment operated under US supervision on host country territory. When an autonomous capability is desirable, again, the United States should only make changes to the rules when they are appropriate on a system-wide basis.

What changes are appropriate? Many have advocated relaxing restrictions on sensitive exports, particularly those related to biotechnology, arguing that their diffusion is inevitable, and that the United States suffers by resisting that spread. Those who make that argument often add that by being part of, rather than resisting, diffusion, the United States can better integrate itself into others' scientific establishments and thus better monitor possible illicit uses of the transferred technology. This latter point is probably oversold; in those states of concern to the United States, government secrecy is likely to be very difficult to penetrate through scientist networks, even if some US scientists participating in cooperative activities were active employees of the US intelligence services. Similarly, cooperation is not likely to reach so deep as to affect the personal standards and norms of all scientists and to turn them away from weapons work in sufficient quantity. Nonetheless, integration has some nonproliferation benefits: it can be used to promote options for defection to possible weapons scientists, and it can provide civilian alternatives for elite scientists where work on weapons programs (as in 1980s Iraq) might otherwise exist. At a regional level, training one state's scientists in technically-intensive arms control monitoring techniques has benefits for monitoring other states in the region.

Finally, hardware should not be the only concern; human capital (skills and knowledge) that can be applied to WMD work need to be considered.[224] Even more so than above, though, a full answer to this challenge is beyond the scope of this paper; a few key points are, nonetheless, in order. Past thinking about controlling physical goods is inadequate, as controlling human capital presents a fundamentally different challenge. Far more than with the case of physical goods, the boundary between safe and dangerous is very fuzzy, and once human capital is diffused, it is even more difficult than hardware to recover.

Three broad schools of thought exist in addressing human capital. The first argues that promoting development is more important than constraining the spread of human capital; hence it does not require a strategy. This approach is dangerous: the proliferation of weapons of mass destruction is a real and significant danger and, given that our goal of promoting science and technology is security-driven, security concerns deserve serious attention. The second school argues that constraining human capital diffusion is worthwhile but not possible in any significant way. This school looks to make the best of a bad situation, often focusing on the potential intelligence benefits of the United States' becoming more intimately involved in Islamic world science. The final school argues, to varying degrees, that human capital can and should be controlled, in the view of some by cutting off nearly all technical cooperation. Most sensible approaches—and most debate—are found at the intersection of the last two schools; the goal of future analysis must be to discover where controls can be effectively applied and, when they cannot, how to minimize the negative consequences.

The Way Forward

Science and technology cooperation is certainly not a panacea, nor would it necessarily benefit the United States to blindly intensify its science and technology cooperation with the Islamic world. Within a sound strategic framework, however, and focusing sharply on improving the US-Islamic world relationship, the potential benefits of such collaboration are undeniable.

224 Alisa Carrigan, "Going Fishing: Can the new EU non-proliferation policies slow the dissemination of nuclear human capital?" paper presented to the European Foreign Policy Conference, July 2004, <http://www.lse.ac.uk/Depts/intrel/EFPC/Papers/Carrigan.doc>, accessed December 28, 2004

There is no doubt that Islamic world states lack science and technology capability, and there is no question that cooperation can ameliorate that problem, and, in turn, help alleviate its consequences. It can strengthen Islamic world economies and bolster human development, helping to lift their people out of poverty and enhancing their sense of dignity and self-respect. These twin strands of progress can help drain the swamps in which terrorism thrives. Cooperation can be used to more effectively address immediate societal problems; it can also be capitalized upon through US diplomacy to build a better image of the United States abroad.

The modern era has consistently seen science and technology cooperation as an important part of the American foreign policy repertoire, and it was deployed consistently and effectively during the Cold War. As the United States faces the global challenges of radicalism and terrorism, political leaders should again harness it today.

Appendix

While science and technology struggle across the Islamic world, pockets of institutional strength—and occasionally excellence—exist. They can form the nuclei of cooperative efforts.[225] To be sure, they are distributed unevenly across disciplines and geographically, and should not be relied upon exclusively by any stretch, but we would be remiss to ignore them. To survey the state of institutions, we interviewed a range of US government officials responsible for funding activities across a host of disciplines and across the Islamic world. We then followed up with brief investigations into the institutions discussed. This survey is not comprehensive, but it is indicative.

Egypt

Cairo University[226] supports a wide range of scientific disciplines, with faculties of computer and informatics sciences, dentistry, engineering, medicine, pharmacology, physiotherapy, science and veterinary medicine. It also includes institutes for cancer and laser research, respectively. The faculty of science has 800 academic staff and 3,360 students. The engineering center for archaeology and environment (ECAE) has a number of collaborative agreements, including an exchange program with France, and an environmental protection program in partnership with the French national institute for industrial environment and risks (INERIS). The Strata Control laboratory of the Nancy School of Mines, associated with INERIS, shares the responsibility of training ECAE engineers in France. There is also a partnership between the High School for Arts and Industries of Strasbourg and the ECAE in the fields of surveying and photogrametry.

Alexandria University[227] has a wide range of scientific faculties: engineering, science (which includes mathematics, physics, chemistry, botany, zoology, geology, oceanography, biochemistry, and environmental studies), medicine, agriculture, nursing, and pharmacy. The university has had research support from the Ford Foundation, the UK Overseas Development Administration (now the Department for International Development[228]), the Program for the Assessment and Control of Pollution in the Mediterranean region,[229] and the Food and Agriculture Organization.

Ain Shams University[230] faculties cover a wide range of

225 Comments from A.B. Zahlan, cited in "Blooms in the Desert," *Nature* 416 (March 14, 2002): 120–122.
226 Cairo University, "Homepage," <http://www.cairo.eun.eg/>, accessed November 29, 2004.
227 Alexandria University, "Homepage," <http://www.alex.edu.eg/>, accessed November 29, 2004.
228 UK Department for International Development, "Homepage," <http://www.dfid.gov.uk/>, accessed December 6, 2004.
229 WHO Regional Office for Europe, "MED POL," <http://www.euro.who.int/eprise/main/WHO/Progs/WSN/CountryActivities/20030617_1>, accessed December 6, 2004.
230 Ain Shams University, "Homepage," <http://net.shams.edu.eg/>, accessed November 29, 2004.

science and technology disciplines: science (encompassing physics, chemistry, geology, biology), pharmacy, dentistry, computer and information science, medicine, nursing, engineering, and agriculture. It underwent significant expansion of its science and technology capability in the 1990s, over which period several of the faculties were founded. On campus there is a private, financially and administratively independent institution known as the Central Laboratory, which was established in 1993 and contains units in various fields of physics, chemistry, geology and biology. The department of chemistry hosts student and faculty exchanges with western countries. Ain Shams University is a participant in the US–Middle East University Partnerships Program, as described in the Department of State section.

Assiut University[231] also has faculties covering a wide range of science and technology domains: computers and information, engineering, medicine, nursing, pharmacy, science (mathematics, physics, chemistry, geology, botany, zoology), and veterinary medicine. The departments within the science faculty have a number of cooperative agreements with universities in other countries. These are for the purpose of enhancing staff and student exchanges, research cooperation and conference management. These agreements are with the University of Caen, France (Assiut Geology and Chemistry Departments), Southern Paris University, France (Faculty of Science), National Aeronautics and Space Administration Center for Earth and Planetary Studies, Smithsonian Institution, Washington, DC, USA (Geology Department), the International Center of Theoretical Physics, Trieste, Italy (Geology Department), Institute of Geology and Oceanography, Hamburg, Germany (Geology Department), Kharkov, Ukraine (Faculty of Science), University of Ferrara, Italy (Chemistry Department), Institute of Material Research, Tohoku University, Japan (Physics Department), Kanazawa University, Japan (Physics Department) and the Leibniz Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany (Zoology Department). The geology department is conducting joint research with Rutgers University in the United States, supported by an NSF grant.

The American University of Cairo[232] carries out undergraduate teaching in a fairly wide range of science and technology departments: computer science, mechanical engineering, construction engineering, electronics engineering, mathematics, biology, chemistry, and physics. Research is more tightly focused, the main science and technology project being the Desert Development Center, which carries agricultural and socioeconomic research, training programs, and community service. The main thrust of the research is to promote sustainable development of Egypt's arid regions. This Center collaborates with a number of Egyptian universities, non-governmental organizations, and government agencies. Amongst these bodies is the Aga Khan Foundation,[233] which itself has partnerships with the Ford Foundation[234] and the Canadian-based International Development Research Center (IDRC).[235] Another is the Egyptian National Research Center (see below).

The National Research Center[236] is affiliated to the Egyptian Ministry of Scientific Research, and is a large multidisciplinary research and development center which focuses on basic applied research. In 2002 it had 5000 employees, around 50 percent of whom were researchers. Its research program is organized into eight fields: medicine, biotechnology, pharmaceutical and medicinal industry, chemical and textile industry, materials sciences and engineering, environment, food and nutritional industry, and agriculture. Three types

231 Assuit University, "Homepage," <http://www.aun.eun.eg/>, accessed November 29, 2004.
232 The American University in Cairo, "Homepage," <http://www.aucegypt.edu/>, accessed November 29, 2004.
233 Aga Khan Foundation Network, "Homepage," <http://www.akdn.org/agency/akf.html>, accessed November 29, 2004.
234 Ford Foundation, "Homepage," <http://www.fordfound.org/>, accessed November 29, 2004.
235 IDRC, "Homepage," <http://www.idrc.ca>, accessed November 29, 2004.
236 National Research Center, Egypt, "Homepage," <http://www.nrc.sci.eg/>, accessed November 29, 2004.

of project are carried out: "in-house" research, contracts with Egyptian-based parties, and contracts with international partners. The list of current or recent partners is impressive: Arab League Educational, Cultural, and Scientific Organization, the Austrian Academy of Science, Center of Sulphur Research in Washington, Czech Academy of Science, DFG/GTZ (Germany), the EU, the Forschungszentrum Julich (Germany), the German Organization for Technical Collaboration, the Institute of Plant Nutrition in Munich (Germany), the IAEA, the International Center for Genetic Engineering and Biotechnology, Trieste (Italy), NATO, the Polish Academy of Science, the US–Egypt Joint Science and Technology Fund, and Wingingin University (Holland).

The Central Metallurgical Research and Development Institute (CMRDI)[237] is also affiliated with the Ministry of Scientific Research. CMRDI "offers services to industry covering research projects, consultancy, technical services, training, testing and certification," and has departments in the fields of minerals, metals, advanced materials and advanced manufacturing. There are also facilities for laser material processing, rapid prototyping manufacturing and analysis and testing services. CMRDI has been accredited by the United States, Germany, Sweden, Japan, and other developed countries to act as a node of technology transfer in the fields of metallurgical and manufacturing techniques from these countries to small and medium scale industrial enterprises in Egypt, the Middle East and Africa. The Project of Upgrading Metal Processing Technology in Egypt is being carried out with the Japan International Cooperation Agency,[238] and CMRDI has also had cooperation with other international agencies such as The Netherlands Organisation for Applied Scientific Research,[239] the Swedish International Development Agency (SIDA),[240] USAID, and the IDRC.

Suez Canal University[241] was established in 1976 and has around 40,000 students studying in 20 faculties on more than 6 campuses. It has a number of science and technology-oriented research centers: Saint Catherine's Environmental Research Center, which focuses on botanical, animal, insect, and geological studies in the South Sinai Zone, the Ismailia Environmental Research Center, which deals with the administration of "socially and economically-oriented environmental projects," the medical center, the agricultural services center, the Abou-Atwa Research Center for Water Recycling, the Ichthyological Research Center, which finds research-based solutions to "national challenges," the Faculty of Agriculture Productive Educational Farm, the Microscope Unit Center, the Marine Center, the Public Service Center for Health, and the Central Lab for Medical and Veterinary Services. The Ichthyological Research Center conducts the Tilapia project, financed by the USAID in collaboration with the University of Maryland, and the Artemia project, financed by the EU and University of Gent, Belgium.

Ethiopia

Science and technology is promoted in Ethiopia by the Ethiopian Science and Technology Commission; university-level teaching is under the aegis of the department of higher education.[242]

In Addis Ababa University (AAU) (15,347 students and 737 teaching staff in the 1995–96 academic year) the faculty of technology[243] includes departments of chemical, civil, electrical and computer, and mechanical engineering, architecture and urban planning, building technology, and material research and testing. The research in the faculty of veterinary medicine is particularly geared to the needs and strengths of Ethiopia,

237 CMRDI, "Homepage," <http://www.cmrdi.sci.eg/>, accessed November 29, 2004.
238 JICA, "Homepage," <http://www.jica.go.jp/english/>, accessed November 29, 2004.
239 TNO, "Homepage," <http://www.tno.nl/>, accessed November 29, 2004.
240 SIDA, "Homepage," <http://www.sida.se/>, accessed November 29, 2004.
241 Suez Canal University, "Homepage," <http://www.suez.edu.eg/>, accessed November 29, 2004.
242 Ethiopia, "Science & Technology," <http://www.ethioworld.com/Science&Technology/science&technology.htm>, accessed November 29, 2004.
243 Addis Ababa University, "Faculty of Technology Homepage," <http://www.telecom.net.et/~aaufot/index-1.htm>, accessed November 29, 2004.

which has the largest livestock population in Africa.[244] Since the 1995–96 academic year, there has been a two-year postgraduate program in Tropical Veterinary Epidemiology, in collaboration with the Faculty of Veterinary Medicine of the Freie Universitaet Berlin. Some components of the departmental research program are funded by the UN Food and Agriculture Organization, and the IAEA; most are supported by the research and publication office of AAU, and the Ethiopian Science and Technology Commission. In the faculty of science, the department of geology and geophysics is currently performing, or has recently performed, research supported by the EU, the French Centre National de la Recherche Scientifique (CNRS), the United Kingdom's National Environment Research Council, the Austrian Science Fund, the Universities of Cagliari and Perugia, Italy, the Swedish Department of Research Cooperation (SAREC) and the IAEA.[245] The department of chemistry has worked with SAREC and SIDA of Sweden, and the German Academic Exchange Service, while research in the department of pathobiology has been supported by the World Health Organization. Paleontology research is being carried out with support from the NSF (as well as the National Geographic Society, the Leakey Foundation, and the Ethiopian Ministry of Culture) and in collaboration with the Ethiopian National Museum and several US universities, including the University of Texas, Washington University, and the University of Michigan.

Jordan

Science and technology policy, strategies, plans and programs in Jordan are determined by the national umbrella body, the Higher Council for Science and Technology, formed in 1988.[246] This manifests Jordan's recognition of "the vital role of science and technology in the sustainable development of various economic sectors." It is composed of the following departments: industry and energy, agriculture and life sciences, mineral resources, health and environment, information technology, economics and finance, water, communications and international relations, and education and human resources, which address the different developmental, medical, technological and scientific objectives that the Council has been set.[247] A collaborative project that is being carried out under the auspices of the Council and the United Kingdom's Royal Geographic Society is the Jordan Badia Research and Development Program,[248] which aims to improve the quality of life of the Bedouin people living in the north-east part of Jordan by "optimum resource utilization, appropriate technology transfer, human resources development, combating desertification, and enhancement of collective initiatives amongst the Badia population." There are several academic and private sector partners, in the United Kingdom and the United States, working with the numerous Jordanian universities in the project.

The Royal Scientific Society (RSS),[249] established in 1970, is one of the scientific and technological centers of the Higher Council for Science and Technology. It is Jordan's largest applied research institution, also providing consultation and technical service. The seven technical centers and departments are the Building Research Center, the Electronic Services & Training Center, the Environmental Research Center, Information Technology Center, the Mechanical Design and Technology Center, the Industrial Chemistry Center, and the Quality Assurance Department. There is also a Renewable Energy Research Center. The RSS has a large number of

244 Addis Ababa University, "Faculty of Veterinary Medicine," <http://www1.vetmed.fu-berlin.de/ip_addis.htm>, accessed November 29, 2004.
245 Department of Geology and Geophysics, "Research Activities," <http://www.geocities.com/asfawossena/research-dgg.htm>, accessed November 29, 2004.
246 The Higher Council for Science and Technology, "Homepage, <http://www.hcst.gov.jo/main.htm>, accessed January 23, 2005.
247 Embassy of the Hashemite Kingdom of Jordan, "Information Bureau: Science & Technology," <http://www.jordanembassyus.org/new/jib/factsheets/science.shtml>, accessed January 26, 2005.
248 Jordan Badia Research and Development Programme, "Homepage," <http://www.badia.gov.jo/>, accessed January 27, 2005.
249 Royal Scientific Society, Jordan, "Homepage," <http://www.rss.gov.jo/>, accessed January 26, 2005.

agreements and protocols with various international scientific and developmental bodies,[250] and is a member of several technical and scientific bodies, including UNESCO and the World Association of Industrial and Technological Research Organizations. The RSS has a number of ongoing international collaborations. It was a participant in the Fourth and Fifth Framework Programmes of the European Union, and cooperation with EU partners has taken place in the fields of information technology and environmental research. The collaboration between the RSS and the Japan International Cooperation Agency has focused on various aspects of computer technology and mechanical design. Governmental, academic and private sector entities in Switzerland have worked with the RSS in the areas of eco-efficiency (cleaner production) and the management of hazardous materials, as well as on a seismic assessment project focused on Aqaba. Cooperation with the Canadian International Development Agency has centered on wastewater management. Other international partners in the environmental research carried out by the RSS include the International Arid Land Consortium,[251] based in the United States, the IDRC,[252] the Swedish SIDA,[253] and USAID.

The University of Jordan[254] was established in 1962 and now has 18 faculties, including science, medicine, nursing, agriculture, educational sciences, engineering and technology, pharmacy, dentistry, and the King Abdullah II School for Information Technology. Most of the research taking place in the faculty of science is geared towards Jordan's plans for development (for example, in pharmaceuticals, health, mining, and materials science). The faculty of engineering and technology, which has 118 teaching staff, covers a broad swathe of engineering disciplines, and awards masters and doctoral degrees. The faculty of medicine has cooperative links with a number of foreign organizations, including the British Royal College of Physicians and Royal College of Obstetrics and Gynecology, the Irish Royal College of Surgeons, the International Red Cross, Montpellier University in France, and the UN Relief and Works Agency. Faculty members and students in the faculty of pharmacy participate in exchange programs with Jordanian and foreign universities, while the faculty of dentistry hosts visiting scholars from the United Kingdom, France, Germany, Italy, Egypt, Iraq, Syria, and the United States. The King Abdullah II School for Information Technology has links with local and international IT firms (such as Microsoft and Intel) and maintains relations with local industry through the Information Technology Association of Jordan.[255] There is also a Water and Environment Research and Study Center, established in 1982, which has cooperative links with Wageningen University, Netherlands, the National University of Ireland, the University of Catania, Italy, and Purdue and Washington State Universities in the United States. This is yet another example of a university's research strength being tailored to the country's particular priorities.

Jordan University of Science and Technology (JUST)[256] was founded in 1986 and now has 11 faculties, comprising 55 departments. The faculties cover a broad range of science and technology: engineering, computer and information technology, medicine, applied medical sciences, dentistry, pharmacy, nursing, science, agriculture, and veterinary medicine. In addition to these teaching faculties, there are numerous research centers: the Queen Rania Al-Abdullah Center for Environmental Science and Technology, the Dental Center, the Health Center, the Veterinary Health

250 Embassy of the Hashemite Kingdom of Jordan, "Information Bureau: Science & Technology," <http://www.jordanembassyus.org/new/jib/factsheets/science.shtml>, accessed January 26, 2005.
251 IALC, "Homepage," <http://ag.arizona.edu/OALS/IALC/Home.html>, accessed January 26, 2005.
252 IDRC, "Homepage," <http://www.idrc.ca/>, accessed January 26, 2005.
253 SIDA, "Homepage," <http://www.sida.se/Sida/jsp/polopoly.jsp?d=107>, accessed January 26, 2005.
254 The University of Jordan, "Homepage," <http://www.ju.edu.jo/>, accessed November 30, 2004.
255 INTAJ, "Homepage," <http://www.intaj.net/>, accessed November 30, 2004.
256 JUST, "Homepage," <http://www.just.edu.jo/>, accessed November 30, 2004.

Center, the Energy Center, the Pharmaceutical Research Center and the Biotechnology Center. Like many other developing universities, JUST is seeking to recruit teachers and researchers who have trained in the West in order to develop the university's capabilities more rapidly.

Yarmouk University[257] has, in addition to a broad spectrum of faculties covering arts and science, seven research centers, including the Center of Theoretical and Applied Physics, the Aqaba Marine Science Center, and the Speech and Hearing Center. The marine science center is linked through cooperation agreements to the Universities of Nice, France, Suez Canal, Egypt, and Essen, Germany, and to the Marine Sciences Center in Basra University, Iraq, and the Sinkinburg Institute, Germany. A recent cooperative project was the International Red Sea Program (RSP), which ran from 1995 to 2000. This was funded by the German Government and involved participants from Germany (Center for Tropical Marine Ecology (ZMT), Bremen), Egypt, Israel, the Palestinian Authority, and Jordan. According to the Yarmouk Center, "the outcome of the RSP was not only good science and collaboration with international institutions during the period of the program, but also establishing firm and sustainable links with many of the institutions that participated in the program." As of May 2003, the Marine Science Center was preparing for a networking project with ZMT, for which the Center would serve as a node in an International network of tropical marine research centers for the Middle East, Arabian Gulf and North Africa. Another noteworthy area of research at Yarmouk concerns water resources, in the Department of Earth and Environmental Sciences. One focus is on the shallow aquifers in north-east Jordan. Clearly in the light of current and future water needs, this research is of increasing importance.

Kazakhstan

The Institute of Nuclear Physics,[258] founded in 1957, performs a range of research under the general umbrella of nuclear physics. The areas covered include basic and applied nuclear physics, solid state physics, radioecology, nuclear power safety and the physics of nuclear reactors, and the development and application of nuclear technologies. The latter area deals with topics such as neutron crystallography, production of radioactive isotopes, and water purification. The Institute also undertakes commercial activity, including the production of industrial materials by radiation treatment, developing equipment for medical applications and tool sterilization, and the production of radioisotopes and radiopharmaceutical preparations. In September 2005, the Institute will host the 5th International Conference on Nuclear and Radiation Physics.

The national (government-owned) atomic company of Kazakhstan is Kazatomprom.[259] It produces natural uranium, nuclear fuel for power stations, products and semi-products of beryllium, tantalum, niobium and its alloys. Kazatomprom is regulated by the IAEA and has partnerships with private companies, non-profit and non-governmental organizations in a number of countries, including Belgium, Canada, China, France, Germany, Japan, Kyrgyzstan, Russia, South Korea, and the United States.

The Climate Change Coordination Center[260] coordinates domestic Kazakh efforts to combat climate change, and manages the country's compliance with international obligations. As well as its administrative and advisory roles, it hosts workshops and meetings, and is currently implementing a number of environmental programs. These include "Institutional Strengthening for Greenhouse Gas Emissions Reduction", which will be partly funded by the UK government, British Gas, Shell, and British Petroleum,

257 Yarmouk University, "Homepage," <http://www.yu.edu.jo/>, accessed November 30, 2004.
258 Institute of Nuclear Physics, "Homepage," <http://www.inp.kz/indexeng.php>, accessed January 26, 2005.
259 Kazatomprom, "Homepage," <http://www.kazatomprom.kz/eng/>, accessed January 26, 2005.
260 Climate Change Coordination Center, "Homepage," <http://www.climate.kz/engl/>, accessed January 26, 2005.

and in which scientists from these companies, the British government and Kazakhstan will work to ensure implementation of greenhouse gas reduction measures, to use new technologies in this effort, to introduce renewable energy resources, and to reduce the power-dependence of the Kazakh economy. Another program phases out the use of ozone-depleting substances in Kazakhstan.

Kyrgyzstan

The National Academy of Sciences of the Kyrgyz Republic[261] is the most broadly-based scientific institution in Kyrgyzstan. Its component institutes cover a wide range of disciplines: mathematics, natural sciences, life sciences, earth sciences, and engineering. The institutes are encouraged to seek foreign partners in their research activities through, for example, the International Association for the Promotion of Cooperation with Scientists from the New Independent States of the Former Soviet Union[262] (an independent organization, of which EU states and others are members, aimed at increasing scientific cooperation with its partner countries, including Azerbaijan, Kazakhstan, Kyrgystan, Tajikistan, Turkmenistan, and Uzbekistan), the EU, and NATO.

Other organizations and institutions in Kyrgyzstan that are carrying out scientific research or development are the Ministry of Ecology and Environment and the Center for the Problems of Renewable Energy Application. There are many environmental issues confronting Kyrgyzstan, the identified priorities being "the irrational management of water resources and their pollution, the degrading of lands, the overuse of forest resources, the threat to biodiversity, and inefficient and polluting practices of mining and processing industry."[263] The role of the Ministry in meeting these challenges is clearly central.

Lebanon

The American University of Beirut[264] supports quite a wide range of science and technology research, from digital signal processing and adaptive filtering through engineering, aerosols, computers, and bioinformatics to biodiversity, molecular and cellular biology, extraction and analytical chemistry, and animal care. The university receives scientific research funding from a number of foreign sources: L'accord de Coopération pour l'Evaluation et le Développement de la Recherche, an agreement between the French and Lebanese governments signed in 1996, TEMPUS,[265] an EU program to aid the development of higher education systems in partner countries, the NSF, TWAS (the academy of sciences for the developing world), and the International Development Research Center. Support from the Lebanese government comes through the Lebanese National Council for Scientific Research.[266] The energy research group joined the Global Network on Energy for Sustainable Development (GNESD)[267] in November 2003 to become one of GNESD's 20 developing world Centers of Excellence. In an initiative sponsored by the US Department of State, this group has advanced an initiative for energy efficiency and renewable energy[268] in partnership with the Jordan University of Science and Technology (see above), the Palestine Polytechnic University, Birzeit University, King Fahd University of Petroleum and Minerals, Damascus University, Florida Solar Energy Center, the North-West Energy Education Institute in Oregon, and PRD Consulting in California. The department of

261 National Academy of Sciences of the Kyrgyz Republic, "Homepage," <http://academ.aknet.kg/index.html>, accessed January 26, 2005.
262 INTAS, "Homepage," <http://www.intas.be/>, accessed January 26, 2005.
263 See discussion of National Environmental Action Plan at Kyrgyzstan Development Gateway, "Ecology," <http://eng.gateway.kg/ecology>, accessed January 26, 2005.
264 American University of Beirut, "Homepage," <http://www.aub.edu.lb/>, accessed November 30, 2004.
265 TEMPUS, "Homepage," <http://www.etf.eu.int/tempus.nsf>, accessed December 1, 2004.
266 CNRS, "Homepage," <http://www.cnrs.edu.lb/research.html>, accessed December 6, 2004.
267 GNESD, "Homepage," <http://www.gnesd.org/>, accessed December 6, 2004.
268 American University of Beirut, "Bulletin Today: June 2004," <http://wwwlb.aub.edu.lb/~webbultn/v5n6/04.html>, accessed January 27, 2005.

agricultural and food sciences has agreements with the International Center for Agricultural Research in the Dry Areas, IDRC, the World Health Organization, USAID, the International Plant Genetic Resources Institute, Kew Gardens in the United Kingdom, the International Foundation for Science,[269] and the European Union. The Center for Research on Population and Health receives funding from the Wellcome Trust, the Mellon Foundation, and the Ford Foundation.

Malaysia

Malaysia aims to be a developed country by 2020,[270] and its universities are very industry-oriented, with spin-off companies and consultancy services common.

The University of Malaya[271] has 12 faculties, which include the built environment, computer science and information technology, dentistry, engineering, medicine, and science. Research in the university is promoted, monitored, and assessed by the Institute of Research Management and Consultancy, which also provides consultancy services to various public and private agencies. This was established in 2000, and reflects the priority which the university attaches to research. The university has a range of collaborative research projects in a number of scientific disciplines: chemistry, biological science, physics, medicine, and engineering. Research partners include the University of Sydney, Murdoch University, the University of Western Australia, the Western Australia Health Export Unit, and the Cooperative Research Center for Waste Management and Pollution Control Limited (Australia), CNRS (France), the University of Frankfurt, the University of Würzburg, the Forschungsinstitut Senckenberg, and the Center for Tropical Marine Ecology (Germany), the University of Leeds, the Southampton Institute, and Queen Mary College (United Kingdom), the Korea Institute of Energy Research, the University of Texas at Arlington, Kyoto University (Japan), and Mycosphere Pte. Ltd. (Singapore), as well as the European Union and the IAEA.

The Science University of Malaysia[272] has over 1,000 academic staff, and since the mid-1990s has focused on research that is "applied, market-driven, or priority-specific,"[273] which accounts for about 70 percent of the total research program. As a consequence, the university has been able to strengthen its industrial links, with the result that new products have been successfully developed and consultancy work has been performed. Much of the research has been organized into centers and units; these include the Center for Drug Research, the Center for Marine and Coastal Studies, the Doping Control Center, the National Poison Center, the Astronomy and Atmospheric Science Research Unit the Computer Aided Translation Unit, and the [disease] Vector Control Research Unit. The Center for Drug Research collaborates in activities funded by the United Nations and the WHO. The Center for Marine and Coastal Studies has three areas of activity: ecosystem studies (in which there is collaboration with universities in the United States, the United Kingdom, Australia, New Zealand, Philippines, Thailand, and Vietnam), marine pollution and toxicology (in collaboration with universities and institutions in Japan, Indonesia, Canada, and Denmark), and mariculture and coral reef research (with collaborators in Japan and the United States). The National Poison Center is a WHO collaborating center for drug information. The university also has collaboration with United Nations Environment Program and other international organizations, while memoranda of understanding, with a research component, have been signed with 22 overseas universities.

269 IFS, "Homepage," <http://www.ifs.se/>, accessed December 6, 2004.
270 Prime Minister's Office, "Vision 2020," <http://www.pmo.gov.my/website/webdb.nsf/vALLDOC/BA7051FF90767AD848256E84003129CA>, accessed January 10, 2005.
271 University of Malaya, "Homepage," <http://www.um.edu.my>, accessed January 2, 2005.
272 Science University of Malaysia, "Homepage," <http://www.usm.my/>, accessed January 2, 2005.
273 Science University of Malaysia, "R&D and Consultancy," <http://www.usm.my/r&d/index.html>, accessed January 2, 2005.

National University of Malaysia[274] has 12 faculties, including allied health sciences, dentistry, engineering, information science and technology, medicine, and science and technology. In addition to the research taking place in these faculties, a number of research centers and institutes have been established: the Center for Advanced Engineering and the Center for Gene Analysis and Technology are linked to the faculties of Science and Technology, and Engineering, respectively. The Interim Laboratory of the National Institute for Genomic and Molecular Biology and the Malaysian Institute of Environment are based near the main campus, facilitating research collaboration between these institutes and university. The Institute for Environment and Development and the Institute of Microengineering and Nanoelectronics (IMEN) support graduate study and research, which also involves international collaborators; IMEN also hosted the 2004 Institute of Electrical and Electronics Engineers International Conference on Semiconductor Electronics. The university has incubated a number of commercial ventures, spun out from its research, and the Center for Research Management works to develop, expand and optimize the university's research program. In the period 2000–2002, the university received $25m in research grants.

The Universiti Putra Malaysia[275] has 15 faculties, the majority of them science-focused. These include agriculture, forestry, veterinary medicine, engineering, science, food science and technology, human ecology, medicine and health science, computer science and information technology, biotechnology and biomolecular sciences, and environmental studies. As well as a broad range of veterinary research, the veterinary faculty has also developed a number of commercial vaccines. The faculty of environmental studies provides consultancy services, as well as operating a research and graduate studies program. The university has five science-related research institutes, in bioscience, advanced technology, multimedia and software, gerontology and mathematical research. These institutes were established from the mid-1990s onwards. The Advanced Technology Institute aims to develop world-class research laboratories in niche areas of advanced technology: automobile technology, advanced materials, bioengineering, computer integrated systems, intelligent systems robotics, spatial numerical modeling, and theoretical studies.

The Technological University of Malaysia[276] has 10 faculties, which include the faculty of chemical and natural resource engineering, the faculty of civil engineering, the faculty of computer science and information systems, the faculty of education, the faculty of electrical engineering, the faculty of geoinformation science and engineering, the faculty of mechanical engineering, and the faculty of science. In addition, there is a center for graduate studies in advanced software engineering, and a large number of research Centers of Excellence, in fields such as automotive development, environmental and water resource management, artificial intelligence and robotics, software, chemical engineering, marine technology and wireless communication, as well as technology policy and international studies. There is research collaboration in artificial intelligence and robotics with universities and companies in Singapore, the United Kingdom, and France, and the Center for Advanced Software Engineering was established in 1996 as a collaboration between the Technological University of Malaysia and Thales, France. The Ibnu Sina Institute for Fundamental Science Studies, which applies basic science in physics, chemistry, biology and mathematics to technological applications, signed a memorandum of understanding with Hokkaido University, Japan, in 2003.

The Malaysia University of Science and Technology (MUST)[277] was established in collaboration with the Massachusetts Institute of Technology (MIT) with the

274 National University of Malaysia, "Homepage," <http://www.ukm.my/english/>, accessed January 2, 2005.
275 Universiti Putra Malaysia, "Homepage," <http://www.upm.edu.my>, accessed January 2, 2005.
276 Technological University of Malaysia, "Homepage," <http://www.utm.my>, accessed January 2, 2005.
277 MUST, "Vision and Mission," <http://www.must.edu.my/vision.html>, accessed January 10, 2005.

aim of being a world class research and development university. MIT's involvement with MUST began in 1995, and it provides assistance to MUST in the following areas: establishment of graduate-level academic programs, research collaboration, outreach seminars, development of a research agenda, and development of MUST's institutional infrastructure. MUST teaches graduate masters courses, and conducts research in ICT, biotechnology, transportation and logistics, materials science and engineering, construction engineering and management, system engineering and management, and photonics. The areas of research collaboration with MIT include transport, ICT, and biochemical engineering. There is also research collaboration with the National University of Singapore and Nanyang Technological University, Singapore, and with private industry, both within Malaysia and abroad.

Morocco

The Ecole Mohammadia d'Ingénieurs (Rabat)[278] is associated with the Université Mohammed V and was opened in 1983. The school trains engineers in a range of disciplines, including civil, electrical, computer, industrial, mechanical, and mineral engineering. Military training also forms a component of the instruction. Research forms the other major thrust of the school's activity, and the international dimension of this is important. EMI has 22 cooperative agreements with foreign universities and schools based predominantly in France, but also in Belgium, Canada, the United States, the United Kingdom, Bulgaria, Spain, and Senegal. There are also extensive links with Moroccan industry, and involvement with numerous international organizations and companies. These include the International Development Research Center, the Arab Contractors Union, the UN Industrial Development Organization,[279] the UN Development Program,[280] the World Health Organization,[281] the Arab Industrial Development and Mining Organization,[282] Belsim SA[283] in Belgium, and Metraflu in France.

The Royal Center for Remote Sensing (CRTS)[284] was established in 1989 to promote the use and development of remote sensing (RS) applications in Morocco. It implements the national RS program; the scientific program involves the acquisition, storage, and distribution of data and images, the observation of the Earth and the development of methodologies for remote sensing, geographic information systems (GIS) and related fields. The research is carried out in cooperation with both Moroccan and foreign research institutions, and CTRS also provides expertise to a range of Moroccan organizations, from public institutions to private companies. The international efforts in which CTRS is involved include the UN's Committee on the Peaceful Uses of Outer Space,[285] Africover,[286] the FAO's initiative to promote the sustainable use of natural resources by establishing a digital georeferenced database on African land cover and a geographic database for the whole continent, while CTRS is also part of organizations such as EURISY,[287] which promotes educational and informative activities to advance space technology and its application in Europe, the International Academy of Aeronautics,[288] the International Astronautical Federation (IAF),[289]

278 EMI, "Homepage," <http://www.emi.ac.ma/>, accessed November 27, 2004.
279 UNIDO, "Homepage," <http://www.unido.org/>, accessed December 1, 2004.
280 UNDP, "Homepage," <http://www.undp.org/>, accessed December 1, 2004.
281 WHO, "Homepage," <http://www.who.int/en/>, accessed December 1, 2004.
282 Arab Industrial Development and Mining Organization, "Homepage," <http://www.arifonet.org.ma/aidmo_us/main.htm>, accessed December 1, 2004.
283 Belsim S.A., "Homepage," <http://www.belsim.com/>, accessed December 1, 2004.
284 CRTS, "Homepage," <http://www.crts.gov.ma/>, accessed November 30, 2004.
285 UN Office for Outer Space Affairs, "COPUOS," <http://www.oosa.unvienna.org/COPUOS/copuos.html>, accessed December 1, 2004.
286 Africover, "Homepage," <http://www.africover.org/>, accessed December 1, 2004.
287 Eurisy, "Homepage," <http://www.eurisy.asso.fr>, accessed December 1, 2004.
288 IAA, "Homepage," <http://www.iaanet.org/>, accessed December 1, 2004.
289 IAF, "Homepage," <http://www.iafastro.com/>, accessed December 1, 2004.

and the International Space University.[290] CTRS also has responsibility for training professionals from different disciplines, and setting up collaborative research and development programs that focus on subjects such as land use, oceanography, desertification, and climate change.

Al-Akhawayn University[291] (AUI) opened in 1995 and is modeled in its organization on the American university system. Science and technology-related teaching takes place in the School of Science and Engineering and the main foci of the degrees awarded are engineering and computer science. The ongoing research is in the fields of remote sensing and geographic information systems (looking at topics such as land use and irrigation), and there is close collaboration with CRTS (see above). There is also collaboration with Clark University and the University of Maryland in the United States. Similar to the case of CRTS, AUI is also engaged in continuing education in RS and GIS technology for researchers and decision-makers, and provides expert consultative advice. Also like CRTS, AUI works through international organizations such as FAO, UNDP, UNESCO and UNEP.[292]

Pakistan

Karachi University[293] has over 12,000 students and 600 teaching staff. The university's science and technology activity takes place under the aegis of the faculties of science, pharmacy and medicine and a wide range of scientific disciplines are covered, ranging from the physical sciences through computer science, geography, food science to the life sciences, as well as mathematics and statistics. The university publishes about 100 papers annually; the publication record of the faculty of pharmacy is particularly notable. There is also a number of research institutes, which includes the Center of Excellence for Marine Biology, the Institute of Marine Science, the Marine Reference and Research Collection Center, the Institute of Clinical Psychology and the HEJ Research Institute of Chemical Sciences. The latter institute[294] is directed by Professor Atta-ur-Rahman, the highly-respected Pakistani chemist and science minister. The Institute is "one of the few research institutes in the Third World where students from Western countries come for training in sciences," and awards almost 20 doctorates annually. In the mid-1990s, the institute was selected by the Third World Academy of Sciences to be the first Third World Center for Sciences and Technology in Chemical Sciences, which makes it a beacon in the developing world. As an example of this, collaborating scientists have come to use the spectroscopic facilities from countries such as Bangladesh, Chile, Ethiopia, Egypt, Ghana, India, Iran, Iraq, Jordan, Mongolia, Sri Lanka, and Turkey. The HEJ Research Institute also has cooperative agreements with organizations in a number of developed countries, such as the United States, Germany, France and the United Kingdom.

Quaid-e-Azam University[295] has a wide range of science and technology departments that carry out both teaching and research: biological sciences, chemistry, computer sciences, earth sciences, electronics, mathematics, physics, and statistics. The mathematics and physics departments are particularly strong; the mathematics department is developing a cooperative agreement with the University of the Witwatersrand, Johannesburg, South Africa, while the physics department has had material and financial input from agencies such as the Japanese Aid Program, the DAAD (Germany), the ICAC Scheme of the Abdus Salam International Center for Theoretical Physics, Trieste (Italy), the International Program in the Physical Sciences, Uppsala (Sweden), as well as the Pakistan

290 ISU, "Homepage," <http://www.isunet.edu/>, accessed December 1, 2004.
291 Al-Akhawayn University, "Homepage," <http://www.alakhawayn.ma/>, accessed November 30, 2004.
292 UNEP, "Homepage," <http://www.unep.org/>, accessed December 1, 2004.
293 University of Karachi, "Homepage," <http://www.ku.edu.pk/>, accessed November 30, 2004.
294 University of Karachi, "HEJ Research Institute of Chemical Sciences," <http://www.ku.edu.pk/research/hej.html>, accessed November 30, 2004.
295 Quaid-i-Azam University, "Homepage," <http://www.qau.edu.pk/>, accessed November 30, 2004.

Science Foundation, the Higher Education Commission and other Pakistani national research organizations. It has collaborations with MIT, University of Virginia, Imperial College (the United Kingdom), Bonn University, Bochum University, and Berlin University (Germany). The research in the department covers a wide range of fields, and the publication record is among the best in Pakistan.

The University of the Punjab[296] is the oldest and largest university in Pakistan. There are ten faculties, which include engineering and technology, pharmacy, medicine and dentistry, and science. The largest is the science faculty, which has 187 academic staff; this faculty is divided into a number of departments (with a particular emphasis on life sciences), institutes and centers. Pakistan has defined a national objective to develop science and technology in general, and the field of biotechnology in particular. The National Center of Excellence in Molecular Biology has agreements with the universities of Washington and Cincinnati in the United States, and Ottawa in Canada. The Center in High Energy Physics collaborates with High Energy Group in Albany, New York and the Max Planck Institute for Nuclear Physics, Heidelberg, Germany. The faculty of engineering includes a research department for coal technology, which is important for the Pakistani economy.

The University of Peshawar[297] has faculties of life and environmental sciences, numerical and physical sciences, and management and information sciences, amongst others. There are also research centers devoted to geology, physical chemistry, and biotechnology, and the Pakistan Forest Research Institute is Pakistan's most important institution in this field. The National Center of Excellence in Geology is particularly strong, having been rated one of the top research institutions in Pakistan by the World Bank (1990) and the US Geological Survey (1992) and is the leading earth sciences institution in the country in terms of the impact factor of its publications. Individual researchers in the university have on-going collaborations with scientists abroad.

The National Institute for Biotechnology and Genetic Engineering (NIBGE)[298] was established in 1994 and has infrastructure of a sufficiently high standard that collaboration with laboratories in developed countries is possible. Research currently takes place in six areas: biofertilizers, bioprocess technology, environmental biotechnology, health biotechnology, industrial biotechnology, and plant biotechnology. Research into cotton leaf curl virus involved cooperation with the University of Arizona, Tuscon, the John Innes Center, Norwich, Imperial College, London and Queen Mary College, London, all in the United Kingdom. This research is now permitting the development of disease-resistant cotton. Research into biofertilizers has been carried out with support from the IAEA and the Islamic Development Bank. In collaboration with Quaid-e-Azam University, Islamabad, the NIBGE is also involved in teaching for masters and doctoral degrees. A biotechnology marketing company called Pakistan Innovative Biotechnology Service was established in 1995 at NIBGE under the auspices of the Pakistan Atomic Energy Commission to commercialize the processes developed through biotechnology research. This has led to the marketing of processes and products in the agricultural, industrial, environmental and health diagnosis domains.

Qatar

The Qatar Scientific and Applied Research Center (SARC)[299] is part of the University of Qatar and aims to conduct and develop basic and applied research, to facilitate technology transfer to wider society, to collaborate with scientific establishments around Qatar and to establish a databank for scientific data

296 University of Punjab, "Homepage," <http://www.pu.edu.pk/>, accessed November 30, 2004.
297 University of Peshawar, "Homepage," <http://www.upesh.edu/>, accessed November 30, 2004.
298 NIBGE, "Homepage," <http://www.nibge.org/>, accessed November 30, 2004.
299 SARC, "Homepage," <http://www.qu.edu.qa/sarc/index33.htm>, accessed November 30, 2004.

and information. The research in progress at SARC covers a wide range of disciplines, including biology, medicine, biochemistry, ecology, engineering, physics (the positron beam project proceeds in collaboration with the University of Cape Town, South Africa), and materials science (the project to tailor surface properties of selected polymers for technical and biomedical applications is being carried out in collaboration with the Institute of Electronic Materials Technology, Warsaw, Poland[300]). External funding sources include Chevron and Qatar Petroleum and its subsidiaries the Qatar Vinyl Company and RasGas.

The Qatar Foundation for Education, Science and Community Development[301] was established in 1995 on the initiative of the Emir of Qatar and operates a network of centers and branch campuses of certain prestigious American universities. Several of the centers deal with education at the primary and secondary levels, and social development, but the Qatar Diabetes Association is involved in research as well as in educating the public about this disease. The science and technology-related branch campuses comprise offshoots of Carnegie Mellon University,[302] where computer science is taught, Weill Cornell Medical College,[303] and Texas A&M University,[304] where engineering is taught. The "Education City," currently under development, is "conceived as a totally integrated educational environment." There is also a Science and Technology Park, due to open in early 2006, which is intended as a base for companies to conduct research and development. It is planned that academics from the institutions in the Education City will collaborate with industrial researchers. Tenants already committed to the Park include Shell, ExxonMobil, Total, EADS and Microsoft. The Park will also foster the development and launch of spin-off products.

Saudi Arabia

The King Abdulaziz City for Science and Technology (KACST)[305] (formerly the Saudi Arabian National Center for Science and Technology) was founded in 1977 and its mission is "the promotion of science and technology in the Kingdom by coordinating and cooperating with various universities, agencies and institutions concerned with research and technology, and encouraging Saudi experts to undertake research that will help promote the development and evolution of the society." KACST has also established several national research institutes, including the Institute for Petroleum and Petrochemicals Research, the Institute of Energy Research, the Institute of Natural Resources and Environmental Research, the Institute of Arid Lands Research, the Institute of Astronomy and the Institute of Atomic Energy Research. KACST itself consists of eight research institutes: atomic energy, astronomy and geophysics, computers and electronics, resources and environment, petroleum and petrochemical, space research, energy research, and mathematics and physics. KACST has in the past engaged in numerous collaborative activities: for example, the SOLERAS project with the United States to develop solar power in the Kingdom, which led to construction of a solar-powered desalination plant, and the HYSOLAR project with Germany, to produce hydrogen using solar energy. Participation in the Saudi–Malaysian, Saudi–Japanese, and Saudi–France technical committees on space technology is another example of KACST international cooperation.

The King Faisal Specialist Hospital and Research Center,[306] founded in 1975, is a technologically advanced hospital which provides high-class care and facilities. The Children's Cancer Center, opened in

300 Institute of Electronic Materials Technology, "Homepage," <http://www.itme.edu.pl/>, accessed November 30, 2004.
301 Qatar Foundation for Education, Science and Community Development, "Homepage," <http://www.qf.edu.qa/>, accessed November 30, 2004.
302 Carnegie Mellon University in Qatar, "Homepage," <http://www.qatar.cmu.edu/>, accessed November 30, 2004.
303 Weill Cornell Medical College in Qatar, "Homepage," <http://www.qatar-med.cornell.edu/>, accessed November 30, 2004.
304 Texas A&M University at Qatar, "Homepage," <http://www.qatar.tamu.edu/>, accessed November 30, 2004.
305 KACST, "Homepage," <http://www.kacst.edu.sa/en/>, accessed November 27, 2004.
306 King Faisal Specialist Hospital and Research Center, "Homepage," <http://www.kfshrc.edu.sa/>, accessed November 30, 2004.

1997, is the only dedicated children's cancer center in the Middle East. The associated research center was opened in 1976 and undertakes a comprehensive program of research in a wide range of fields, including cancer, cardiovascular diseases, biomedical physics, biostatistics, epidemiology, scientific computing, radioisotopes, radiopharmaceuticals, genetics, and ethics. The research center has the only cyclotron and positron emission tomography facilities in the Middle East.

There is some documented international collaboration: in 1988 the Radiation Dosimetry Laboratory of the Biomedical Physics Department was accepted as a member of the joint IAEA/WHO Network for Secondary Standard Dosimetry Laboratories, while there is a pharmacogenomics research link with the University of Brighton in the United Kingdom.

Senegal

The Université Cheikh Anta Diop de Dakar[307] has a number of science and technology departments: the Institut des Sciences de l'Environnement, the Centre d'Etudes des Sciences et Techniques de l'Information, the Institut de Recherches sur l'Enseignement de la Mathématique, de la Physique et de la Technologie, the Ecole Supérieure Polytechnique (including Génie Chimique et Biologie Appliquée, Génie Civil, Génie Électrique et Maintenance Industrielle, Génie Informatique et Télécommunication, Génie Mécanique), the Institut des Sciences de la Terre, the Faculté de Medecine Pharmacie d'Odonto-Stomatologie, and the Faculté des Sciences et Techniques. There are cooperative research agreements[308] with universities in Europe (Belgium, Spain, France, Italy), the Americas (the United States, Canada, Brazil), Asia (Iran), Africa (Mali, Morocco, Sudan, the Democratic Republic of Congo), most of which are scientific or multidisciplinary. There is also a public health research cooperation agreement with the Institut Pasteur de Dakar[309] (which itself has research cooperation with the EU on tropical diseases and epidemics, with South America in the AMSUD-Pasteur organization[310] and with the university of Hong Kong and the Pasteur Institutes of Shanghai and Korea).

Tunisia

The Université de Tunis el Manar[311] was created in November 2000 and is primarily focused on scientific disciplines. The university is composed of four faculties, two of which are medicine and mathematical, physical and natural sciences. There is also an engineering school, and higher institutes of applied biological sciences, computer science, human sciences, and medical technology. Two establishments devoted to research are the Institut Pasteur, and the Institut de Recherche Vétérinaire de Tunis. There is international cooperation between the university and foreign counterparts in "all aspects of higher education and scientific research." Partners include organizations such as l'Agence universitaire de la Francophonie, UNESCO, Unione delle Università del Mediterraneo, and the Association of Arab Universities,[312] as well as numerous universities in Italy, France, Belgium, Germany, Switzerland, Serbia, Canada, Japan, Democratic Republic of Congo, South Africa, Mauritania, and Libya. As described in the Department of State section, the Université de Tunis el Manar also participates in the US–Middle East University Partnerships Program. The university operates the ManarTech seedbed for creating and nurturing innovative businesses, as described immediately below.

307 Université Cheikh Anta Diop de Dakar, "Homepage," <http://www.ucad.sn/>, accessed November 27, 2004.
308 Université Cheikh Anta Diop de Dakar, "Coopération," <http://www.ucad.sn/rubrique.php3?id_rubrique=197>, accessed November 27, 2004.
309 Institut Pasteur de Dakar, "Homepage," <http://www.pasteur.sn/>, accessed November 27, 2004.
310 AMSUD-Pasteur, "Homepage," <http://amsudpasteur.edu.uy/>, accessed November 27, 2004.
311 L'université de Tunis el Manar, "Homepage," <http://www.utm.rnu.tn/>, accessed December 1, 2004.
312 AARU, "Homepage," <http://www.aaru.edu.jo/>, accessed January 10, 2005.

Ecole Nationale d'Ingénieurs de Tunis (ENIT)[313] was founded in 1968 and is the foremost engineering university in Tunisia; it is associated with the Université de Tunis el Manar. It both trains engineers up to the doctoral level and has a research program. ENIT collaborates with a number of French universities (for example, the Ecole Nationale des Ponts et Chaussées de Paris, the Ecole Supérieure du Génie Industriel de Grenoble, and the Ecole Nationale Supérieure des Arts et Industries Textiles) in its undergraduate training program, while in its doctoral research program there are bilateral or multilateral initiatives through which researchers can spend time abroad. Participant countries in this cooperation include France, Spain, Morocco, Portugal, Italy, Germany, Canada and the United States. Administrators can spend periods of time in the Middle East and North Africa division of the EU's TEMPUS program to improve their experience and methods. Another interesting aspect of ENIT's activities is its participation in the initiative to facilitate the development of commercial enterprises, established by the Université de Tunis el Manar in 2002. This has several aspects: taught modules that deal with the creation of innovative companies, a Masters degree in the creation of companies and management of innovation, ManarTech, guided by ENIT and managed by the university, which develops such companies, and ENIT-Incubation, a framework that aids the development of projects generated by ManarTech. ManarTech has succeeded in producing a number of hi-tech companies[314] that operate in the fields of e-commerce (eXénon), gene therapy (Cryo-Service) and digital television (Applied New Technologies). Others currently at the incubation stage involve soil improvement engineering (SimPro), developing telemetry and telecommunication applications (Innov-Com), and map digitization (Géomatica).

Institut National des Sciences Appliquées et de Technologie (INSAT)[315] was formed because of Tunisia's "desire to equip itself with an essential instrument for its economic and social development." Teaching there began in 1996, and by 2001 there were 1,821 students spread over the five full years of the engineering degree. INSAT has partnerships with the industrial sector, international cooperation with a number of countries and engages in applied research, all of which have enabled it to "hoist itself onto the level of the major universities and engineering faculties in Tunisia."

University of Sfax for the South[316] was founded in 1986 as part of the initiative to decentralize higher education in Tunisia. It performs teaching in the fields of medicine, science and engineering. There are a number of schools and institutes attached to the university, including the National Engineering School of Sfax (ENIS),[317] the Higher Institute of Technical Studies of Sfax[318] and the Biotechnology Center of Sfax.[319] ENIS has four research laboratories and eight research units, plus a laboratory for environmental science. The laboratory research covers the fields of energy, environment, electronics, IT and electromechanics, while the units specialize in biotechnology, biochemistry, microbiology, industrial chemistry, system control, energy management, geoscience and materials science. International cooperation takes place with many French universities and institutions, and others in Spain, Morocco, the United Kingdom, Belgium, Canada, Russia, and Mauritania. ISET has departments in the fields of agriculture and food science, chemical analysis, civil engineering, mechanical engineering, materials science and engineering, and statistics. Through the MAN-FOR program, ISET has forged close links with university institutes of technology in Reims, Toulouse, Bethune, and Valenciennes

313 ENIT, "Homepage," <http://www.enit.rnu.tn/fr/home/indexfr.php> (in French), accessed November 30, 2004.
314 ManarTech, "Entreprises déjà Crées," <http://www.enit.rnu.tn/fr/ouverture/ppt/EntreprisesdeManartech.ppt>, accessed December 1, 2004.
315 INSAT, "Homepage," <http://www.universites.tn/insat/francais/bienvenue/index.htm> (in French), accessed November 30, 2004.
316 University of Sfax for the South, "Homepage," <http://www.uss.rnu.tn/>, accessed November 30, 2004.
317 ENIS, "Homepage," <http://www.mes.tn/enis/index.htm>, accessed December 1, 2004.
318 ISET, "Homepage," <http://www.isetsf.rnu.tn/>, accessed December 1, 2004.
319 Biotechnology Center of Sfax, "Homepage," <http://www.rnu.tn/cbs/>, accessed December 1, 2004.

(all in France). These have taken the form of student and industrial exchange, training of lecturers, and industrial cooperation. ISET also has partnerships with local industry in the Sfax region, and acts as a seedbed for the business ideas put forward by its young graduates by helping them with know-how and facilities. CBS is a research-oriented entity that has four laboratories: for enzymes and metabolites of prokaryotes, for molecular genetics of eukaryotes, for biopesticides and for biotechnology. There are also three units: for molecular genetics of plants, for the utilization of research results, and for information and scientific documentation. Part of the mission of CBS is to assist local companies in their development, and to give rise to new industries. As well as collaborations with other research centers in Tunisia, the laboratories have links with a number of institutions in France, as well as others in Germany, Morocco, Sweden, Portugal, the United Kingdom, Libya, Canada, Belgium, Austria, Turkey, Italy, Spain, Australia, and Egypt. The unit for molecular genetics of plants collaborates with the University of Connecticut, the Institute for the Molecular Biology of Plants, Barcelona, Spain, and Centre de coopération internationale en recherche agronomique pour le développement in Montpellier, France.

Turkey

Bogazici University[320] receives funding from the EU Sixth Framework Programme in the fields of genomics and biotechnology for health, information society technologies, nanotechnologies and nanosciences, aeronautics and space. There is a "mechatronics" research and applications center,[321] and polymer research that is funded by NIH and NSF, among others.

At Koç University[322] there are three scientific "research centers," which focus on computational biology and bioinformatics, micro-nano technologies and opto-electronics. These transcend the individual science departments, which have their own research programs. The university receives funding from the EU Sixth Framework[323] Programme for a number of research projects. The optical microsystems laboratory receives funding from the NSF, as well as a number of international companies. There is also a program to allow one faculty member per annum to visit Harvard University.

Marmara Research Institute[324] also receives funding from the EU Sixth Framework Programme in the following fields: genomics and biotechnology for health, information society technologies, nanotechnologies and nanosciences, space, sustainable fuel technologies, and ecosystems. The Information Technologies Research Institute has collaborators in many European countries, and Arizona State University. The Energy Systems and Environmental Research Institute includes NATO-supported research; there are projects in the Food Science and Technology Research Institute supported by NATO, and conducted in collaboration with the German Technical Cooperation Organisation; in the Materials and Chemical Technologies Research Institute there has been research supported by NATO and for whom the client was General Electric Aircraft Engines; the Earth and Marine Sciences Research Institute has collaboration with a number of US institutions, including MIT, as well as others in France, Germany, Italy, Switzerland and Azerbaijan.

Middle East Technical University[325] (METU) has cooperative agreements with 15 advanced countries, and the physics department conducts plasma and nuclear fusion research at the TEXTOR tokamak in Germany,

320 Bogazici University, "Homepage," <http://www.boun.edu.tr/index_eng.html>, accessed November 27, 2004.
321 Bogazici University, "Unesco Chair on Mechatronics and Mechatronics Research and Application Center," <http://mecha.ee.boun.edu.tr/>, accessed November 27, 2004.
322 Koç University, "Homepage," <http://www.ku.edu.tr/>, accessed November 29, 2004.
323 European Commission, "Sixth Framework Programme: 2002–2006," <http://europa.eu.int/comm/research/fp6/index_en.html>, accessed December 29, 2004.
324 Tubitak, "MRC," <http://www.mam.gov.tr/english/>, accessed November 27, 2004.
325 METU, "Homepage," <http://www.metu.edu.tr/>, accessed December 29, 2004.

and works with CERN (the European center for research in nuclear and particle physics), NASA and high energy physicists from Japan. The collaborative research at METU funded by the NSF was mentioned earlier, in the NSF section.

Bilkent University[326] was founded in 1984 through foundations established by the university's founder, and has recruited faculty from 43 countries, many of whom were based in North America or Europe prior to taking their position in Bilkent. In terms of research publications per faculty member it is the foremost Turkish university. The faculty of science is composed of four departments: mathematics, physics, chemistry, and molecular biology and genetics, while the faculty of engineering has three departments: computer engineering, electronics and electrical engineering, and industrial engineering. The language of teaching is English, and the university is a party to student exchange programs with about 20 universities outside Turkey, as well as collaborative projects. Bilkent is a member of the SOCRATES and ERASMUS schemes, which are EU initiatives that encourage the exchange and students and faculty between European universities, as well as the European Mobility Scheme for Physics Students, an exchange program coordinated by the European Physical Society. Bilkent is an interesting model as it was only recently founded and has been tailored to the aim of being an international university of high standing.

Uzbekistan

The largest scientific organization in Uzbekistan is the Academy of Sciences.[327] Its component branches include physical and mathematical sciences, mechanics, processes of control and informatics, chemical sciences, earth sciences, biological sciences, and medical sciences. The Institute of Nuclear Physics[328] is reportedly the strongest entity within the Academy, and carries out both basic and applied nuclear physics research. It is also commercially active, producing reactor and cyclotron isotopes, labeled compounds and isotope sources, superpurified (up to 99.9999%) metals, measuring and controlling apparatus, and filters for air and water purification. It is a partner institution of the Cooperative Monitoring Center and Sandia National Laboratory. Another noteworthy facility is the solar furnace at the Institute of Material Science. This is one of the two most powerful such furnaces in the world, and has been used for the development of materials, especially ceramics. The resulting materials have numerous applications, based on their durability and radiation-hardness, and the technological knowledge gained from operating the furnace is being applied to the construction of solar installations.

State Committee of the Republic of Uzbekistan on Geology and Mineral Resources monitors the geological environment of the Republic, exogenous processes, the state of ground waters, and maintains the inventory of the latter. Research is carried out in fulfillment of its role.

The Technology Transfer Agency[329] was created by the Center for Science and Technologies of the Uzbek Cabinet of Ministers, and is the first organization in Uzbekistan aimed at facilitating technology transfer, commercialization of intellectual property, and implementing strategy for innovation projects, as well as the projects themselves.[330] These projects have three main themes: environmental projects (environmental risks, combating desertification, greenhouse gas abatement, water resources management), technology transfer projects using renewable energy (especially solar energy), and innovative projects on local capacity building and raising public awareness. Particular fields of interest are photovoltaic systems, solar water heating, heat

326 Bilkent University, "Homepage," <http://www.bilkent.edu.tr/>, accessed November 29, 2004.
327 The Academy of Sciences of Uzbekistan, "Homepage," <http://eng.uzsci.net/academy/>, accessed January 26, 2005.
328 Institute of Nuclear Physics, "Homepage," <http://www.nti.org/db/nisprofs/uzbekis/fulltext/romes.htm>, accessed January 26, 2005.
329 Technology Transfer Agency, "Homepage," <http://www.nature.uz/about/att.php>, accessed January 26, 2005.
330 E-mail from Camille Caliendo, US Department of Energy, January 13, 2005.

pumps, and hybrid solar/wind power. Production of photovoltaic modules and systems is carried out by FOTON, a company (which was previously a military plant) that also produces consumer electronics.

The National University of Uzbekistan[331] has 15 faculties, including computer science, geology, biology, chemistry, physics and mathematics. The physics department has ongoing collaboration with universities in Japan, and Italy, and is a beneficiary of the EU's TEMPUS program. The renewable energy laboratory in the associated Institute for Applied Physics carries out research on photovoltaic systems, which has led to interaction with the US Department of Energy.

The Government of Uzbekistan has an ongoing effort to encourage potential partners from the EU to engage in collaboration funded by the EU's Sixth Framework Programme.[332] There are a number of other programs, under the auspices of the European Union, United Nations, NATO and various NGOs that can fund research in Uzbekistan.[333]

331 National University of Uzbekistan, "Homepage," <http://www.nuu.uz/>, accessed January 26, 2005.
332 Uzbekistan FP6 National Information Point, "Homepage," <http://fp6nip.uzsci.net/eng/index.php>, accessed January 26, 2005.
333 Uzbekistan FP6 National Information Point—Science in Uzbekistan, "Homepage," <http://fp6nip.uzsci.net/eng/science/index.php>, accessed January 26, 2005.

Definitions

Science and Technology

This paper defines science and technology as the natural and health sciences (science), and their practical application (technology).

Several other definitions of science and technology have been proposed for the study of its relationship to the developing world. Perhaps the most expansive definition has been adopted in several RAND studies, which define science simply as the accumulation of knowledge, and technology as the application of knowledge. This would not generally be accepted as an accurate definition of modern science, in which the method of accumulating knowledge is central to the discipline, a method that US policy should promote the adoption of. Furthermore, this definition is too broad to be useful; for example, it would even include the study of history. More careful, yet still expansive, definitions of science include all areas that could traditionally be considered science, including all social sciences. While this is an intellectually sound definition, it too is not the most useful one for our purposes. Most importantly there is no clear applied (technology) counterpart to the social sciences; perhaps public policy is the best candidate, but though the United States may want to influence public policy in Islamic world states, that would be too broad a mandate for this study. The most narrow definition of science and technology would consider only the natural sciences, but would leave out health sciences and associated "technology", or practice.

The Islamic world

The scope of study for this paper defines the Islamic world as those states whose populations are at least 50 percent Muslim.

This is perhaps the most restrictive definition that might be adopted; broader definitions may be appropriate, and could be used as bases for future studies. A slightly less restrictive definition would include states with minority Muslim populations, but only when those populations were still large at an absolute level (the most obvious example of this is India, which is only 12 percent Islamic, but which has more Muslim citizens than any other countries except Indonesia and Pakistan).

Cooperation

This paper defines science and technology activities as cooperative if they involve scientists, engineers, or health practitioners from both the United States and a host country, with participants from both sides exploiting their specialized training.

This definition could be made more restrictive, to require that participants from both sides learn new skills or create new knowledge—this would exclude, for example, training efforts (the US participants gain no new skills). It could be expanded to include arrangements where US scientists exploit their training, but foreign scientists do not—this would include, for example, arrangements where US scientists are given access to resources in the Islamic world, but do not work with scientists there, and scenarios where US health practitioners operate in the Islamic world. Note that our definition excludes activities where US scientists study the Islamic world as a subject without the active cooperation of Islamic world colleagues.

The Brookings Project on U.S. Policy Towards the Islamic World

The *Brookings Project on U.S. Policy Towards the Islamic World* is a major research program housed in the Saban Center for Middle East Policy at the Brookings Institution. It was designed to respond to some profound questions that the terrorist attacks of September 11th raised for U.S. foreign policy. The project seeks to develop an understanding of the forces that led to the attacks, the varied reactions in the Islamic world, and the long-term U.S. policy responses. In particular, the project examines how the United States can reconcile its need to eliminate terrorism and reduce the appeal of extremist movements with its need to build more positive relations with the wider Islamic world.

The project has several interlocking components:

- The U.S.–Islamic World Forum, which brings together American and Muslim world leaders from the field of politics, business, media, academia and civil society, for discussion and dialogue;

- A task force of specialists in Islamic, regional, and foreign policy issues (emphasizing diversity in viewpoint and geographic expertise), as well as government policymakers, who meet regularly to discuss, analyze, and share information on relevant trends and issues;

- A visiting fellows program that brings distinguished experts from the Islamic world to the Saban Center at Brookings;

- A series of analysis papers and monographs that provide needed analysis of the vital issues of joint concern between the U.S. and the Islamic world;

- A Brookings Institution Press book series, which will explore U.S. policy options towards the Islamic world, the objective of which is to synthesize the project's finding for public dissemination.

The project convenors are Stephen Philip Cohen, Brookings Institution Senior Fellow; Martin Indyk, Director of the Saban Center; and Shibley Telhami, Professor of Government at the University of Maryland and Non-Resident Senior Fellow at the Saban Center. Peter W. Singer, National Security Fellow at the Brookings Institution, is the Project Director.

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Alina Romanowski, *Director, Near East-South Asia Center for Strategic Studies, National Defense University.*

Dennis Ross, *Counselor, The Washington Institute.*

Faisal bin Salman Al-Saud, *Professor, King Saud University.*

Jillian Schwedler, *Assistant Professor of Government, University of Maryland.*

Richard Solomon, *President, United States Institute of Peace.*

S. Frederick Starr, *Research Professor and Chairman of the Central Asia-Caucasus Institute, SAIS, Johns Hopkins University.*

James Steinberg, *Vice President and Director, Foreign Policy Studies, The Brookings Institution.*

Jessica Stern, *Lecturer in Public Policy, Kennedy School of Government.*

Ray Takeyh, *Senior Fellow, Council on Foreign Relations.*

Puneet Talwar, *Senate Foreign Relations Committee Staff.*

Marvin Weinbaum, *Scholar-In-Residence, Middle East Institute.*

Hillel Weinberg, *House International Relations Committee Staff.*

Robin Wright, *Staff Writer,* The Washington Post.

Fareed Zakaria, *Editor,* Newsweek International.

The Saban Center for Middle East Policy

The Saban Center for Middle East Policy was established on May 13th, 2002 with an inaugural address by His Majesty King Abdullah II of Jordan. The establishment of the Saban Center reflects the Brookings Institution's commitment to expand dramatically its research and analysis of Middle East policy issues at a time when the region has come to dominate the U.S. foreign policy agenda.

The Saban Center provides Washington policymakers with balanced, objective, in-depth and timely research and policy analysis from experienced and knowledgeable people who can bring fresh perspectives to bear on the critical problems of the Middle East. The center upholds the Brookings tradition of being open to a broad range of views. Its central objective is to advance understanding of developments in the Middle East through policy-relevant scholarship and debate.

The center's establishment has been made possible by a generous founding grant from Haim and Cheryl Saban of Los Angeles. Ambassador Martin S. Indyk, Senior Fellow in Foreign Policy Studies, is the Director of the Saban Center. Kenneth M. Pollack is the center's Director of Research. Joining them is a core group of Middle East experts who conduct original research and develop innovative programs to promote a better understanding of the policy choices facing American decision makers in the Middle East. They include Tamara Wittes who is a specialist on political reform in the Arab world; Shibley Telhami who holds the Sadat Chair at the University of Maryland; Shaul Bakhash an expert on Iranian politics from George Mason University; Daniel Byman from Georgetown University, a Middle East terrorism expert; and Flynt Leverett a former senior CIA analyst and Senior Director at the National Security Council who is a specialist on Syria and Lebanon. The center is located in the Foreign Policy Studies Program at Brookings, led by Vice President and Director, James B. Steinberg.

The Saban Center is undertaking original research in six areas: the implications of regime change in Iraq, including post-war nation-building and Gulf security; the dynamics of the Iranian reformation; mechanisms and requirements for fulfilling a two-state solution to the Israeli–Palestinian conflict; policy for Phase III of the war on terror, including the Syrian challenge; and political change in the Arab world.

The center also houses the ongoing Brookings *Project on U.S. Policy Towards the Islamic World* which is generously funded by the State of Qatar and directed by National Security Fellow Peter W. Singer. The project focuses on analyzing the problems that afflict the relationship between the United States and the Islamic world with the objective of developing effective policy responses. It includes a task force of experts, an annual dialogue between American and Muslim intellectuals, a visiting fellows program for specialists from the Islamic world, and a monograph series.

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