

Steven E. Miller & Scott D. Sagan

*Nuclear power without
nuclear proliferation?*

Today, the Cold War has disappeared but thousands of those weapons have not. In a strange turn of history, the threat of global nuclear war has gone down, but the risk of a nuclear attack has gone up. More nations have acquired these weapons. Testing has continued. Black market trade in nuclear secrets and nuclear materials abound. The technology to build a bomb has spread. Terrorists are determined to buy, build or steal one. Our efforts to contain these dangers are centered on a global non-proliferation regime, but as more people and nations break the rules, we could reach the point where the center cannot hold.

– President Barack Obama
Prague, April 5, 2009

The global nuclear order is changing. Concerns about climate change, the volatility of oil prices, and the security of energy supplies have contributed to a widespread and still-growing interest in the future use of nuclear power. Thirty states operate one or more nuclear power plants today, and according to the International Atomic Energy Agency (IAEA), some 50 others have requested

© 2009 by the American Academy of Arts
& Sciences

technical assistance from the agency to explore the possibility of developing their own nuclear energy programs. It is certainly not possible to predict precisely how fast and how extensively the expansion of nuclear power will occur. But it does seem probable that in the future there will be more nuclear technology spread across more states than ever before. It will be a different world than the one that has existed in the past.

This surge of interest in nuclear energy – labeled by some proponents as “the renaissance in nuclear power” – is, moreover, occurring simultaneously with mounting concern about the health of the nuclear nonproliferation regime, the regulatory framework that constrains and governs the world’s civil and military-related nuclear affairs. The Nuclear Non-Proliferation Treaty (NPT) and related institutions have been taxed by new worries, such as the growth in global terrorism, and have been painfully tested by protracted crises involving nuclear weapons proliferation in North Korea and potentially in Iran. (Indeed, some observers suspect that growing interest in nuclear power in some countries, especially in the Middle East, is not unrelated to Iran’s uranium enrichment program and Tehran’s movement closer to a nuclear weapons

capability.) Confidence in the NPT regime seems to be eroding even as interest in nuclear power is expanding.

This realization raises crucial questions for the future of global security. Will the growth of nuclear power lead to increased risks of nuclear weapons proliferation and nuclear terrorism? Will the nonproliferation regime be adequate to ensure safety and security in a world more widely and heavily invested in nuclear power? The authors in this two-volume (Fall 2009 and Winter 2010) special issue of *Dædalus* have one simple and clear answer to these questions: It depends.

On what will it depend? Unfortunately, the answer to that question is not so simple and clear, for the technical, economic, and political factors that will determine whether future generations will have more nuclear power without more nuclear proliferation are both exceedingly complex and interrelated. How rapidly and in which countries will new nuclear power plants be built? Will the future expansion of nuclear energy take place primarily in existing nuclear power states or will there be many new entrants to the field? Which countries will possess the facilities for enriching uranium or reprocessing plutonium, technical capabilities that could be used to produce either nuclear fuel for reactors or the materials for nuclear bombs? How can physical protection of nuclear materials from terrorist organizations best be ensured? How can new entrants into nuclear power generation best maintain safety to prevent accidents? The answers to these questions will be critical determinants of the technological dimension of our nuclear future.

The major political factors influencing the future of nuclear weapons are no less complex and no less important. Will Iran acquire nuclear weapons; will

North Korea develop more weapons or disarm in the coming decade; how will neighboring states respond? Will the United States and Russia take significant steps toward nuclear disarmament, and if so, will the other nuclear-weapons states follow suit or stand on the sidelines?

The nuclear future will be strongly influenced, too, by the success or failure of efforts to strengthen the international organizations and the set of agreements that comprise the system developed over time to manage global nuclear affairs. Will new international or regional mechanisms be developed to control the front-end (the production of nuclear reactor fuel) and the back-end (the management of spent fuel containing plutonium) of the nuclear fuel cycle? What political agreements and disagreements are likely to emerge between the nuclear-weapons states (NWS) and the non-nuclear-weapons states (NNWS) at the 2010 NPT Review Conference and beyond? What role will crucial actors among the NNWS – Japan, Iran, Brazil, and Egypt, for example – play in determining the global nuclear future? And most broadly, will the nonproliferation regime be supported and strengthened or will it be questioned and weakened? As IAEA Director General Mohamed ElBaradei has emphasized, “The nonproliferation regime is, in many ways, at a critical juncture,” and there is a need for a new “overarching multilateral nuclear framework.”¹ But there is no guarantee that such a framework will emerge, and there is wide doubt that the arrangements of the past will be adequate to manage our nuclear future effectively.

The authors in both this and the subsequent volume address these and other vexing issues that will affect the spread of nuclear power and the spread

of nuclear weapons. As is necessary to understand such a complex set of real-world issues, the authors represent diverse academic disciplines (including physical sciences, engineering, and social sciences) and many professions (including lawyers, nuclear regulators, nuclear industry executives, and experienced diplomats and political leaders). As is appropriate to address a global issue, the authors come from many different countries, from both NWS and NNWS. And as is appropriate for an objective intellectual enterprise, the authors represent both strong advocates for and skeptics of the global expansion of nuclear power, as well as both supporters and opponents of complete nuclear weapons disarmament.

In this introductory essay, we aim first to demonstrate why the question of which states will develop nuclear power in the future matters for global security. To do so, we briefly discuss the connections between nuclear power, nuclear proliferation, and terrorism risks; we present data contrasting existing nuclear-power states with potential new entrants with respect to factors influencing those risks. Second, we introduce major themes addressed by the authors in both volumes, and explain why the expansion of nuclear power, the future of nuclear weapons disarmament, and the future of the NPT and related parts of the nuclear control regime are so intertwined. Finally, we conclude with some observations about what is new and what is not new about current global nuclear challenges. The American Academy of Arts and Sciences has published three important special issues of *Dædalus* on nuclear weapons issues in the past – in 1960, 1975, and 1991 – and reflecting on the differences between the concerns and solutions discussed

in those three issues and the nuclear challenges we face today is both inspiring and sobering.

Although many experts talk about the “expansion” or “renaissance” of nuclear power around the globe, it is important to differentiate between two related phenomena: a potential *growth* in the production of nuclear energy in states that currently have nuclear power facilities and the potential *spread* of nuclear power plants and related facilities to states that are new entrants to the “nuclear energy club.” Figure 1 lists the existing nuclear-power states and the aspiring states that have requested IAEA assistance in exploring nuclear programs, by regions of the world. With respect to climate change, it would, in theory, make relatively little difference which nations increase their use of nuclear energy (and other non-carbon-producing energy technologies); what matters is the overall global reduction in carbon emissions. With respect to the safety and security dimensions of the nuclear future, however, it will matter greatly which states acquire what kinds of nuclear technology. Thus, there are three broad reasons to be concerned about an unconstrained spread of nuclear power to new nations that have not previously managed the technology.

First, for nuclear energy programs to be developed and managed safely and securely, it is important that states have domestic “good governance” characteristics that will encourage proper nuclear operations and management. These characteristics include low degrees of corruption (to avoid officials selling materials and technology for their own personal gain as occurred with the A.Q. Khan smuggling network in Pakistan), high degrees of political stability (defined by the World Bank as

Nuclear power without nuclear proliferation?

Figure 1
Expansion versus Spread: Existing and Aspiring Nuclear Power States

Americas	Western Europe	Eastern Europe	Central and South Asia	East Asia/Oceania	Middle East	Africa
Existing Nuclear Power States	Existing Nuclear Power States	Existing Nuclear Power States	Existing Nuclear Power States	Existing Nuclear Power States	Existing Nuclear Power States	Existing Nuclear Power States
Argentina	Belgium	Armenia	India	China	Iran	South Africa
Brazil	Finland	Bulgaria	Pakistan	Japan	Aspiring Nuclear Power States	Aspiring Nuclear Power States
Canada	France	Czech Republic	Aspiring Nuclear Power States	Korea		
United States	Germany	Hungary	Aspiring Nuclear Power States	Aspiring Nuclear Power States	Bahrain	Algeria
Mexico	Netherlands	Lithuania		Bangladesh	Egypt	Ghana
Aspiring Nuclear Power States	Spain	Romania	Georgia	Indonesia	Israel	Kenya
	Sweden	Russia	Kazakhstan	Malaysia	Jordan	Libya
Bolivia	Switzerland	Slovakia	Mongolia	Myanmar	Kuwait	Morocco
Chile	United Kingdom	Slovenia	Sri Lanka	Philippines	Oman	Namibia
Dominican Republic		Ukraine		Singapore	Qatar	Nigeria
El Salvador		Aspiring Nuclear Power States		Thailand	Saudi Arabia	Senegal
Haiti				Vietnam	Syria	Sudan
Jamaica		Belarus			Turkey	Tanzania
Peru		Croatia			UAE	Tunisia
Uruguay		Estonia			Yemen	
Venezuela		Greece				
		Latvia				
		Poland				

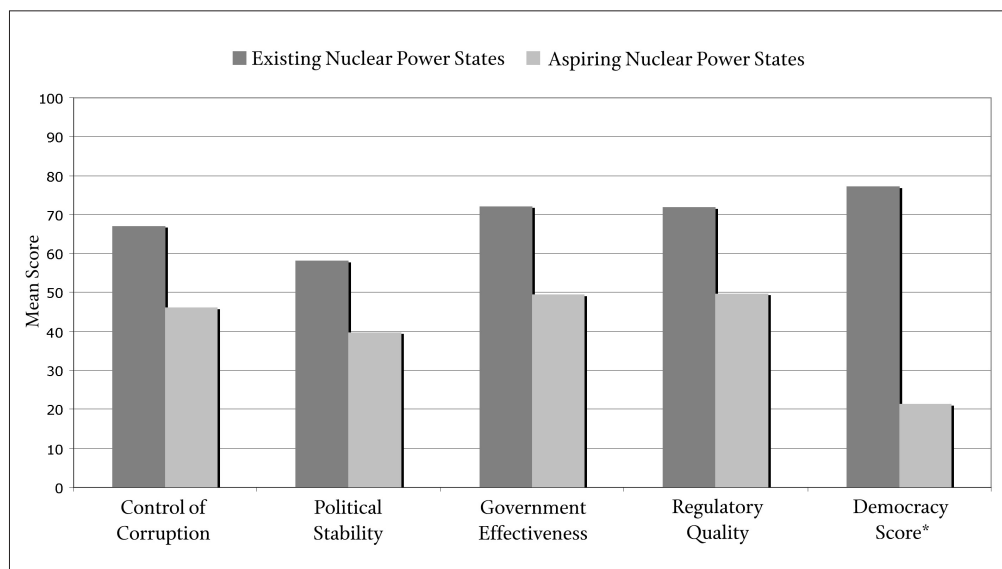
Sources: IAEA Power Reactor Information System, www.iaea.org/programmes/a2; Frank N. von Hippel, ed., "The Uncertain Future of Fission Power," review draft, www.fissilematerials.org; Polity IV Project, *Political Regime Characteristics and Transitions, 1800 - 2007*, www.systemicpeace.org/inscr/inscr.htm.
Figure © Scott D. Sagan.

"likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism"), high governmental effectiveness scores (a World Bank aggregate measure of "the quality of the civil service and the degree of its independence from political pressures [and] the quality of policy formulation and implementation"), and a strong degree of regulatory competence. Fortunately, we have a great deal of information measuring these domestic good governance factors across the globe. Unfortunately, the data highlight the grave security challenges

that would be created if there were rampant proliferation of nuclear energy production facilities to each and every state that has expressed interest to the IAEA in acquiring nuclear power. The World Bank publishes annual aggregate data, derived from multiple sources, on each of these good governance characteristics, and, as shown in Figure 2, the average scores of the potential new nuclear-energy states on each of these dimensions is significantly lower than the scores of states already possessing nuclear energy.

Second, all NNWS under the NPT must accept IAEA safeguards inspections

Figure 2
Governance, Corruption, and Democracy



Nuclear power without nuclear proliferation?

*Measurement for Democracy Score is mean Polity IV score on a 100-point scale. Sources: World Bank, *World Governance Indicators, 1996 – 2007*, info.worldbank.org/governance/wgi/index/asp; Polity IV Project, *Political Regime Characteristics and Transitions, 1800 – 2007*, www.systemicpeace.org/inscr/inscr.htm. Figure © Scott D. Sagan.

on their nuclear power facilities in order to reduce the danger that governments might cheat on their commitments not to use the technology to acquire nuclear weapons; therefore, it is illuminating to examine the historical record of NNWS violating their NPT commitments. Here there is one very important finding about how domestic political characteristics influence the behavior of NPT members: each known or strongly suspected case of a government starting a secret nuclear weapons program, while it was a member of the NPT and thus violating its Article II NPT commitment, was undertaken by a non-democratic government.² (The confirmed or suspected historical cases of NPT member states starting nuclear weapons programs in violation of their Treaty commitments include North and South Korea, Libya, Iraq, Yugoslavia, Taiwan, Iran, and Syria, all of which

were non-democratic at the time in question.) It is therefore worrisome that, as Figure 2 shows, the group of potential new states seeking nuclear power capabilities is on average significantly less democratic than the list of existing states with nuclear energy capabilities.

Third, states that face significant terrorist threats from within face particular challenges in ensuring that there is no successful terrorist attack on a nuclear facility or no terrorist theft of fissile material to make a nuclear weapon or dirty bomb. Figure 3 displays data from the United States Counterterrorism Center comparing the five-year totals of terrorism incidents in the existing states that have nuclear power facilities and the IAEA list of aspiring states. India and Pakistan, both of which have nuclear weapons and nuclear power facilities and which face severe terrorist

Figure 3
Nuclear Power and Terrorism

Incidents of terrorism in past five years, current nuclear power states		Incidents of terrorism in past five years, current and aspiring nuclear power states	
India	4,462	India	4,462
Pakistan	3,687	Pakistan	3,687
Russia	1,302	Thailand*	3,301
Spain	313	Israel*	2,775
France	277	Russia	1,302
United Kingdom	220	Philippines*	1,061
Iran	56	Sri Lanka*	702
China	31	Turkey*	403
Mexico	29	Algeria*	327
Ukraine	25	Spain	313

Asterisk denotes aspiring nuclear power state. Source: Worldwide Incidents Tracking System, National Counterterrorism Center (NCTC), <http://wits.nctc.gov/Main.do>. Figure © Scott D. Sagan.

threats from homegrown and outsider terrorist organizations, clearly lead the pack. But as Figure 3 shows, the states that are exploring developing nuclear power would take up six of the slots on a “terrorist top ten risk list” if each of them develops civilian nuclear power in the future.

These figures clearly represent worst-case estimates about the security implications of the spread of nuclear power, for as a number of authors in these volumes note, many of the aspiring states will not be able to progress with nuclear power development programs any time soon due to financial or other constraints. Indeed, most of the growth in nuclear power over the coming decade is likely to come from new plants in states that already operate nuclear power plants. But the figures do dramatically highlight the intertwined political, technical, and economic challenges we face if the world is to see both the expansion and spread of the use of nuclear power on a global scale. It seems almost certain

that some new entrants to nuclear power will emerge in the coming decades and that the organizational and political challenges to ensure the safe and secure spread of nuclear technology into the developing world will be substantial and potentially grave. The proposals in these two volumes – for international control of the fuel cycle, for sharing best practices for physical security, and for enhancing the international nuclear safety regime – are designed to mitigate the inherent security risks that the nuclear renaissance will bring.

The essays collected in these two volumes of *Daedalus* focus on three broad, interlocking subjects: nuclear power, nuclear disarmament, and nuclear proliferation. The new nuclear order that will emerge years hence will be the result of the interplay of state motives for pursuing nuclear power and constraints on that pursuit. Contributors to the volumes consider in detail the changing technical, economic, and

environmental factors that are making nuclear power seem more attractive around the globe. But they also address factors inhibiting the growth of nuclear power: enormous capital costs, the need for public subsidies, limited industrial capacity to build power plants, inadequate electricity grids, the possible emergence of alternative energy technologies, concern about the cost and risks associated with nuclear wastes, public fear of nuclear technology, as well as concern about the security risks created by the possible spread of weapons-usable nuclear technologies. When the constraints are taken into account, it may well be that the spread of nuclear power will be neither as fast nor as extensive as many anticipate.³ Nevertheless, some expansion and spread seems inevitable, and accordingly these volumes consider the standards for safety and physical protection that must be met to reduce the risks that could emerge along with the spread of civilian nuclear power capacity.

Concerns about proliferation (whether to states or terrorists) arise at the intersection of nuclear power and nuclear weapons. Indeed, the connection between power and weapons is somewhat inevitable because key technologies in the nuclear sector – notably, uranium enrichment and plutonium reprocessing capabilities – are relevant to both. In the nonproliferation context, this is the dual-use dilemma: many technologies associated with the creation of a nuclear power program can be used to make weapons if a state chooses to do so. When a state seems motivated to acquire nuclear weapons, a nuclear power program in that state can appear to be simply a route leading to the bomb or a public annex to a secret bomb program. The crisis over Iran's nuclear activities is a case in point. Depending on what

capabilities spread to which states, especially regarding uranium enrichment and plutonium reprocessing, a world of widely spread nuclear technologies could be a world in which more states, like Iran, would have the latent capability to manufacture nuclear weapons. This could easily be a world filled with much more worry about the risk of nuclear proliferation – and worse, a world where more states possess nuclear weapons. A fundamental goal for American and global security is to minimize the proliferation risks associated with the expansion of nuclear power. If this development is poorly managed or efforts to contain risks are unsuccessful, the nuclear future will be dangerous.

What can be done to limit future proliferation risks? The contributors to these volumes explore two fundamental answers to that question. First, some authors discuss policies that could create a world in which the incentives to acquire nuclear weapons are minimized. If nuclear weapons remain the currency of the realm, if they are the ticket to the high table of international politics, if they are believed to confer enormous diplomatic and security benefits, if the existing NWS insist on the necessity to retain their nuclear weapons for the indefinite future, then it will be very difficult over the long run to make the case that for all other states nuclear weapons are unnecessary and undesirable. On the other hand, the context for future nuclear decision-making will be very different if that context is a world where nuclear weapons are being devalued and marginalized and where the NWS are reducing their arsenals and perhaps even heading meaningfully in the direction of eliminating nuclear weapons altogether. This is why the nuclear disarmament debate comes into play in considering the future global nuclear order.

The disarmament-nonproliferation connection is formally codified in the famous Article VI of the NPT, which calls for the NWS (and all other states) to make good faith efforts to achieve nuclear disarmament. Under the general rubric of arms control, work over several decades has gone toward efforts to regulate, constrain, reduce, and eliminate nuclear weapons – efforts that have helped contain the dangers of nuclear rivalry. Nevertheless – and despite their obligations under Article VI and their repeated rhetorical commitments to nuclear disarmament – the NWS have not, in the opinion of many observers, moved genuinely and significantly in the direction of nuclear disarmament.⁴ Indeed, there have been multiple statements by some government officials in NWS that suggest that they are firmly committed to keeping nuclear weapons indefinitely, and the failure of the U.S. Senate to ratify the Comprehensive Test Ban Treaty (CTBT) and help bring that Treaty into force opens up the prospect of testing new nuclear weapons in the future. The result has been growing dissatisfaction among many key NNWS about the failure of the NWS to live up to their NPT obligations, recurrent acrimonious collisions over Article VI at NPT review conferences, mounting frustration with and disaffection from the NPT regime, and a consequent protracted inability to address other key NPT issues in a constructive fashion. From the perspective of many NNWS, Article VI was one of the core bargains of the NPT and the weapons states are simply not living up to their end of the bargain.

The current debate over nuclear disarmament is crucial to the evolution of the global nuclear order for two reasons. One way or the other, the debate will influence future incentives to acquire nuclear weapons, and it will have signifi-

cant implications in terms of preserving, effectively managing, and strengthening the NPT regime. It is therefore very important that nuclear disarmament has now made it onto the public and policy agenda in a prominent way, having been galvanized by the efforts of four distinguished American statesmen and reinforced by President Obama's remarkable embrace of the nuclear disarmament objective in his speech in Prague in April 2009.⁵ It is generally understood that nuclear disarmament is a long-term goal, not an immediate policy objective. Yet much can be done in the interim to constrain nuclear forces and reduce their role in international politics; such steps can help to address the concerns that have commonly arisen in the nonproliferation context. The origins, rationale, meaning, and prospects of nuclear disarmament are therefore addressed in these volumes of *Daedalus*.

Future proliferation risks can also be limited in a second fundamental way: by preserving and improving the nonproliferation regime, that system of rules and institutions that is meant to allow the use of civilian nuclear power while providing reassurance against the use of nuclear technology for weapons purposes. As the protracted nuclear crises of recent decades – Iraq, Iran, North Korea – have shown, the system is not perfect or foolproof even today. But looking to the future, will the nonproliferation regime be adequate in a world where there is more nuclear knowledge and technology spread across more states? The essays collected in the second volume confront that question. Some of the essays explore various ways in which the nonproliferation regime could be improved: transparency could be enhanced, safeguards bolstered, the IAEA further empowered to monitor nuclear programs and ex-

plore suspicious activities. NPT rules can be more uniformly and universally enforced, with exceptions like the U.S.-India nuclear deal not permitted. The nuclear fuel cycle can be organized in a way that minimizes the spread of sensitive dual-use technology; various schemes for assuring fuel supplies could reduce the need and incentive for individual states to acquire enrichment capabilities, for example. Any fuel-cycle arrangement or agreed norm that limits the spread of enrichment and reprocessing technology will greatly circumscribe the proliferation risks associated with expanded nuclear power. It would also be desirable to find more effective methods of enforcement when instances of noncompliance are discovered. These ideas and more are examined in volume two.

But the NPT is a nearly global regime – all but four states are members (Israel, India, and Pakistan never joined, and North Korea withdrew in 2003) – and none of the ideas for improving the regime will be feasible if they do not inspire wide assent among NPT members. The regime therefore must be considered from a diverse set of national perspectives in order to gauge what steps might be possible and what constraints will need to be addressed in order to adapt the nonproliferation regime to the emerging global nuclear order. It is far from certain that key NNWS will share the diagnoses and support the remedies preferred by the Western nonproliferation community.⁶ The essays in these *Dædalus* volumes address these contrasting perspectives, and the decision to include authors from multiple NWS and NNWS was designed to ensure that the analysis does not suffer from American-centric or NWS biases.

The growth and spread of nuclear power raises a set of concerns about the

risk of nuclear proliferation and nuclear terrorism; working on the problem of nuclear proliferation raises the issue of nuclear disarmament. These topics do not completely overlap, but it is not possible to think comprehensively about the future of the global nuclear order without considering them together and without appreciating the extent to which they are interrelated.

This two-volume special issue of *Dædalus* represents the fourth time that the American Academy has dedicated its journal to issues concerning arms control and nuclear weapons. Special issues were published on “Arms Control” in 1960, on “Arms, Defense, and Arms Control” in 1975, and on “Arms Control: Thirty Years On” in 1991. It is valuable to look back on the articles in these volumes, and the strategic issues upon which they focused, in order to appreciate the significant successes that have occurred in the past, as well as to understand the enduring nature of many of the problems we face and the novelty of some emerging challenges.

The 1960 volume, a product of a special summer study at the American Academy, is widely recognized as a seminal contribution to the development of arms control as a tool to reduce the danger of nuclear war and to manage Soviet-U.S. relations. Indeed, it has been called “the Bible” of arms control, and “the Cambridge school” has been credited with identifying and promoting three key insights that helped maintain nuclear peace during the height of Cold War tensions.⁷ First, the authors strongly argued for the creation of a high threshold between conventional military forces and nuclear forces, in stark contrast to the earlier plans developed during the Eisenhower administration to use nuclear weapons earlier

in any conflict with the Soviet Union or the People's Republic of China – the so-called Massive Retaliation doctrine. Second, while the *Dædalus* authors cannot be credited with being the first to identify the maintenance of “secure second-strike forces” as a prerequisite for nuclear deterrence stability (credit for that insight belongs to Albert Wohlstetter and Warren Amster⁸), the *Dædalus* authors were the first to argue that the pursuit of secure second-strike forces was a *mutual* interest between the USSR and the United States, and thus that arms control negotiations could usefully seek constraints on offensive and defensive forces with this form of strategic stability as an objective. Third, the *Dædalus* authors identified the prevention of the spread of nuclear weapons to new nations as a key national security interest and arms control objective. Again, this was an innovative argument coming at the end of the Eisenhower administration, which had widely distributed nuclear power technology under the Atoms for Peace program and was considering providing nuclear weapons to U.S. NATO allies in Europe.

The 1960 *Dædalus* authors went on to become a veritable “Who’s Who” of arms control during the Cold War, both in terms of scholarship and government service: Herman Khan, Edward Teller, Henry Kissinger, Paul Doty, Thomas Schelling, and Hubert Humphrey. All were relatively young men at the time, but they were to play even more important roles in developing U.S. grand strategy and arms control in subsequent years. With the benefit of hindsight, however, it is as interesting to note the major future security issues that were *not* addressed in the 1960 volume as it is to recognize those that were. Concerns about nuclear pro-

liferation focused primarily on states within U.S. and Soviet alliance systems – in NATO and the Warsaw Pact, and to a lesser degree, China. The idea that many states in what was then deemed the “third world” might be capable of producing nuclear weapons was generally beyond the horizon of vision for the authors.⁹ Similarly, future fears about the danger of nuclear terrorism were simply not on the intellectual agenda of the early 1960s: indeed, it is noteworthy that in his *Dædalus* essay Herman Khan feared what he called “nuclear diffusion” primarily because it would provide nuclear weapons to “criminal organizations” and give the Soviets a new opportunity “to act as agent-provocateurs.”¹⁰ Finally, it bears mentioning that the 1960 “Bible” of arms control was written entirely by American authors. In the Cold War atmosphere of 1960, Americans might speculate on Soviet or Chinese views about nuclear weapons, but it was not possible for experts or policy-makers from either Communist state to contribute directly to the emerging literature.

Much had changed by the time the special issue on “Arms, Defense, and Arms Control” appeared in 1975. As suggested by the title, arms control had become a significant part of U.S. foreign policy, and many of the essays were now devoted to analyzing how best to balance potential arms control agreements with the Soviet Union with perceived U.S. national security requirements for secure and effective nuclear weapons delivery systems. In contrast with the 1960 authors, many of whom used early game theory methods and assumed “rational actors” inside both the United States and the Soviet Union, the 1975 *Dædalus* authors developed new ideas about how domestic politics, organizational interests,

and bureaucratic politics influenced defense programs and arms negotiations.¹¹ The NPT had been negotiated and had come into force in 1970, and that development, coupled with India's 1974 test of a "peaceful nuclear explosive," led to much more attention on proliferation dangers in the developing world. This *Dædalus* issue therefore had a much less bilateral Soviet-U.S. focus, with essays addressing the spread of nuclear weapons and other advanced military systems from the superpowers to third-world states around the globe.¹² Nevertheless, the discussion was still taking place exclusively among Americans, and not one expert from an allied nation, much less a Cold War rival or a neutral third-world state, contributed to the 1975 *Dædalus* volume.

The contributions to the 1991 volume, "Arms Control: Thirty Years On," were written amid great geopolitical change, as the Cold War ended and the Soviet Union was breaking into separate independent states. It is not entirely surprising therefore that many of the essays – indeed, even the volume's title – have a historical emphasis: looking in the rear-view mirror at the role of arms control in the Cold War, albeit with attempts to use that history to predict possible future trends. The 1991 volume did have more international authors, with a leading Russian nuclear strategist, Andrei Kokoshin (who was soon to become a senior Ministry of Defense official), contributing an essay, along with articles by leading European arms control specialists Lawrence Freedman and Johan Jørgen Holst.¹³ Many of the specific arms control topics addressed in the volume, such as the conventional weapons balance in Europe and the

spread of chemical weapons, are simply no longer as significant a concern today as they were in the waning years of the Cold War and the start of a new, uncertain era in international politics. Other issues addressed by the *Dædalus* contributors, however, notably the failure of leading powers to negotiate a CTBT and concerns about the fragility of the NPT and its future ability to constrain states from acquiring nuclear weapons, remain as salient today as they were in 1991.

This special double issue on "The Global Nuclear Future" thus stands in a proud line of *Dædalus* volumes seeking to bring new ideas into the global public policy debate about how to reduce the risks of nuclear proliferation and nuclear weapons use. We do so, however, in the context of a new global topic: how to manage the potential growth and spread of nuclear power. And this special double issue includes far more voices from NNWS, among U.S. allies and others in the developing world, because their governments' decisions will be as important in determining the global nuclear future as are decisions made in Washington.

We hope that the analyses presented in these *Dædalus* volumes will inform and influence policy debates in both NWS and NNWS in the future. Today, the nature of the global nuclear future remains highly uncertain. What is clear is that the decisions we make in the coming years regarding arms control and disarmament, the spread of nuclear power technology, and the reform of international regimes will strongly determine whether a hopeful or frightening nuclear future emerges just over the horizon.

ENDNOTES

- ¹ Mohamed ElBaradei, "Nuclear Energy: The Need for a New Framework," International Conference on Nuclear Fuel Supply: Challenges and Opportunities, Berlin, Germany, April 17, 2008; www.iaea.org.
- ² The evidence is presented in Harald Müller and Andreas Schmidt, "The Little Known Story of De-Proliferation: Why States Give Up Nuclear Weapon Activities," in *Forecasting Proliferation*, ed. William Potter (Stanford, Calif.: Stanford University Press, forthcoming, 2010).
- ³ For an excellent overview, see Sharon Squassoni, *Nuclear Energy: Rebirth or Resuscitation?* (Washington, D.C.: Carnegie Endowment for International Peace, 2009).
- ⁴ See Christopher A. Ford, "Debating Disarmament: Interpreting Article VI of the Treaty on the Non-Proliferation of Nuclear Weapons," *The Nonproliferation Review* 14 (3) (2007): 402–428, and Scott D. Sagan, "Good Faith and Nuclear Disarmament Negotiations," in *Abolishing Nuclear Weapons: A Debate*, ed. George Perkovich and James A. Acton (Washington, D.C.: Carnegie Endowment for International Peace, 2009), 203–212.
- ⁵ See George P. Shultz, William J. Perry, Henry A. Kissinger, and Sam Nunn, "A World Free of Nuclear Weapons," *The Wall Street Journal*, January 4, 2007.
- ⁶ See Deepti Choubey, *Are New Nuclear Bargains Attainable?* (Washington, D.C.: Carnegie Endowment for International Peace, 2008).
- ⁷ This paragraph follows the excellent analysis in Jennifer E. Sims, "The American Approach to Nuclear Arms Control: A Retrospective," *Dædalus* 120 (1) (Winter 1991): 251–272.
- ⁸ Albert Wohlstetter, "The Delicate Balance of Terror," *Foreign Affairs* (January 1959), and Warren Amster, "A Theory for the Design of a Deterrent Air Weapons System" (San Diego: Convair-General Dynamics Corporation, 1955).
- ⁹ For exceptions see Paul Doty, "The Role of Smaller Powers," William T. R. Fox, "Political and Diplomatic Prerequisites of Arms Control," and Herman Kahn, "The Arms Race and Some of its Hazards," all from *Dædalus* 89 (4) (Fall 1960).
- ¹⁰ Kahn "The Arms Race and Some of its Hazards," 777.
- ¹¹ See especially Graham T. Allison and Frederic A. Morris, "Armaments and Arms Control: Exploring the Determinants of Military Weapons," and John Steinbruner and Barry Carter, "Organizational and Political Dimensions of Strategic Posture: The Problems of Reform," both from *Dædalus* 104 (3) (Summer 1975).
- ¹² See especially F. A. Long, "Control from the Perspective of the Nineteen-Seventies," and Abram Chayes, "Nuclear Arms Control after the Cold War," both from *Dædalus* 104 (3) (Summer 1975).
- ¹³ A. A. Kokoshin, "Arms Control: A View from Moscow," Johan Jørgen Holst, "Arms Control in the Nineties: A European Perspective," and Lawrence Freedman, "Arms Control: Thirty Years On," all from *Dædalus* 120 (1) (Winter 1991).