

Introduction: The Search for Strategic Stability in a New Nuclear Era

Robert Legvold & Christopher F. Chyba

The world has entered a new nuclear era whose characteristics and challenges differ markedly from those of the Cold War. No longer dominated by only two nuclear superpowers (even if Russia and the United States still possess the lion's share of nuclear weapons), its dangers are at least as great as those during the Cold War, and made more so by a general unawareness of the multiplying ways a nuclear war could begin. Five nuclear-armed states – China, India, and Pakistan, in addition to Russia and the United States with its allies Britain and France – now set the contours of a multisided matrix, determine whether and when nuclear weapons will be used, and bear the responsibility for deciding whether and by what means the risk of nuclear war can be averted. Other states with nuclear weapons, such as North Korea, further complicate the picture by creating additional pathways to nuclear conflict and generating U.S. responses that stir Russian and Chinese opposition and counteractions. Israel's nuclear arsenal remains recessed and opaque. Beyond this changing geostrategic topography, advances in weapons technology and the opening of new frontiers, such as cyber capabilities and artificial intelligence, make a shifting environment still more complex.

The collapse of the Soviet Union and, with it, the fading fear of nuclear war led to a general disregard of nuclear issues in key relationships, with the exception of the security of nuclear holdings in former Soviet Republics, including Russia. Nuclear states and their defense planners continued to tend to their nuclear forces while adjusting their role to a reality no longer centered on the prospect of a war between two nuclear hegemonies. Aided by the arms control agreements between the superpowers in the last years of the Cold War and the first years after, and by the positive hopes for a new and constructive relationship between the United States and Russia, the world's nuclear states welcomed this less tense reality.

Attention in the United States shifted to threats associated with the nuclear ambitions of countries like Iran and North Korea, and to the possibility of nuclear terrorism. True, by the turn of the century, Russia and China had begun to emphasize what each saw as elements of an ongoing U.S. nuclear threat, and the United States now included both in the scenarios guiding its efforts to refine its extended deterrence commitments in Europe and Asia. But this recrudescence of concern over nuclear trends largely flowed along channels of familiar thought rather than turning national attention to the formidable new challenges of a multipolar nuclear world.

The evolution from what was fundamentally a two-sided order into today's more multifarious setting adds complexity and gives a new dimension to familiar challenges and dangers. We highlight five. Some changes are a matter of multiplication. Originally limited to the United States and the Soviet Union, competitive and potentially adversarial nuclear relationships have expanded to include India and Pakistan, the United States and China, India and China, and in the likely future, the United States and North Korea. In the twentieth century, the United States and Soviet Union developed elaborate triads of nuclear weapons on land, at sea, and in the air. Now, while the United States and Russia are modernizing and enhancing all three legs of their triads, three new countries – China, India, and Pakistan – are fashioning triads of their own. In several of these state pairings, the interactions are not simply bilateral, but are affected by actions directed at third parties. For instance, Pakistan interprets India's nuclear posture toward China as a message meant for itself. China's positioning toward the United States evokes India's apprehensions. When the United States deploys missile defense systems to offset a North Korean nuclear threat, China and Russia react to it as the camel's nose under a tent eventually designed for them. And the competition between offensive and defensive systems reopened between the United States and Russia by the resumption of efforts to develop ballistic missile defense systems is now mirrored by Chinese and Indian moves in the same direction.

Second, technological advancement, a constant driver of change since the dawn of the nuclear age, plays an increasingly diverse and mixed role in today's nuclear setting. Technologies that, as advocates argue, offer more effective deterrence by increasing the usability and therefore the credibility of nuclear weapons, and increase the flexibility and confidence of those with their finger on the nuclear trigger also present novel complications. They raise concern over the survivability of nuclear forces, blur the line between conventional and nuclear war-fighting, risk transforming space warfare into an integral part of nuclear warfare, and, in a crisis, potentially decrease decision-making time. For instance, new conventionally armed hypersonic boost-glide and cruise missiles provide decision-makers

with options for executing extended-range strategic strike missions short of nuclear use, but if they obscure from an opponent whether they are, in fact, nuclear-armed, they also threaten crisis stability. Smaller, lower-yield, and more-accurate nuclear warheads make the threat of their use more credible, but that is because they are also more usable, creating tension between effective deterrence and the risk of lowering the threshold to nuclear war. A variety of remote sensing technologies promise improved information for decision-making in a nuclear crisis and, perhaps, more effective defenses, but simultaneously may render even hard-to-locate mobile missile systems vulnerable to attack. And while emerging cyberspace surveillance capabilities may provide unparalleled real-time information about others' nuclear forces and activities, they may also accentuate others' sense of vulnerability to nuclear-, conventional-, or cyberattack.

Third, concepts key to understanding the original Cold War nuclear era are either under stress or undergoing unpredictable change. Strategic deterrence and its nuclear component take on more complex colorations when nuclear and non-nuclear deterrence are integrated and the task – as has been acknowledged by both U.S. and Russian planners – is to transform nuclear and conventional weapons along with cyber and other hybrid tools into a “comprehensive deterrence” mosaic. Internal to the concept of nuclear deterrence, some countries are again focusing on “limited nuclear options” and thinking through their calibration, while others are struggling with whether their minimum deterrence postures need to be altered: either by developing counterforce options – that is, a capability and strategy for disarming the other side of its nuclear weapons – or by considering a “launch under attack” retaliatory option. Taken together, this whole array of challenges raises the question of whether there can be crisis stability in a cluttered, heterogeneous nuclear environment and, if so, on what basis. Even the standard that came to underpin the notion of crisis stability in the U.S.-Soviet relationship – mutual assured destruction (MAD) based on each side's ability to retaliate massively after a nuclear first strike – seems to some either too narrow or too imperiled.

Fourth, the already-contested realm of nuclear norms – shared principles that shape or have potential in the future to shape the behavior of nuclear actors – is growing increasingly murky and unsettled. The “nuclear taboo” – that is, the questioned ethics of nuclear use – seems further weakened by the attention given to the development of weapons for limited, and therefore more plausible, nuclear use. Flatly rejected by the United States and Russia, the formal “no-first-use” nuclear doctrines of China and India waver as India identifies exceptions to its application and China weighs its feasibility in the face of threats it sees from the United States. Meanwhile, an international movement for a treaty banning nuclear weapons has gathered momentum among the majority of countries that do not have nuclear weapons, and its long-term effects in the parallel universe of public opinion is unclear.

Finally, the dangers of the earlier nuclear era remain: some familiar, some in altered form, and to them are added new ones. The risk of inadvertent nuclear war remains, but now the pathways to it have multiplied across more regions and relationships. The Cold War potential for misreading the other side's nuclear thinking and plans swells when it extends to a larger and diverse set of nuclear actors. The accumulated conceptual refinement and residual understanding on nuclear issues built between the United States and the Soviet Union were the result of fifty years of strategic nuclear arms negotiations and dialogue; this shared understanding has no modern counterpart in any other bilateral or trilateral nuclear relationship. Further, the risk of nuclear conflagration during the Cold War – serious at key crisis moments – arose principally in a single relationship. It is now present in several.

Particularly significant, the original Cold War nuclear competition was gradually moderated by progress in bilateral strategic nuclear arms control arrangements reached from 1969 to 2010. The new era has slowly dismantled this bilateral arms control framework, with no clear prospect that it will be revived and extended. Even more remote is the possibility that a framework or frameworks encompassing other, let alone all, nuclear powers can be achieved.

The authors in this issue of *Dædalus* – a mix of security scholars, physicists, statesmen, and political scientists – address these and other dimensions of this new multipolar nuclear era. Their analyses are sensitive to the challenges and potential dangers posed by a world with nine nuclear players, but also consider developments and measures within their respective spheres that could alter or mitigate these challenges and dangers. The result is not a comprehensive exploration of all facets of a changing nuclear environment. Not all nuclear relationships or the dynamics in all regions are addressed. Rather, the focus is on salient aspects of the change underway among the major nuclear powers, with a primary emphasis on the United States, Russia, and China. The intent is to capture the essential features of the nuclear world we have entered, and to stimulate among policy-makers and the engaged public a recognition of the challenges that it poses. Other dimensions, such as the effects of domestic politics on the choices countries are making, receive limited treatment.

Integral to the creation of this issue of *Dædalus* has been the collaboration among its authors. First in a planning session and then in an authors' review conference, they have been generous in responding to one another's work, raising questions, offering suggestions, and wrestling with areas of disagreement. We are confident they would agree that, as a result, the analyses and arguments the reader will encounter are sharper and more refined than when the exercise began. And the exercise broadly is one, we believe the authors would also agree, that policy-makers in the major nuclear powers, their expert communities, and engaged publics need to replicate.

The analysis is divided into three parts. The essays in part one explore how an evolving world of multiple nuclear powers interacts within a larger international setting that, too, is in motion. A fractured and convulsive international environment now includes multiple tension-laden nuclear pairings, several of which are complicated by nuclear third parties. Steven Miller, in his essay “A Nuclear World Transformed: The Rise of Multilateral Disorder,” considers this altered landscape and assesses its larger implications. He notes that the former overarching bilateral nuclear relationship now coexists with a series of regional nuclear subsystems in South Asia, East Asia, and the Middle East, and ponders the consequences. He assesses what it means that this new, multidimensional nuclear order is “functionally unregulated,” that the gap between the core and lesser nuclear powers has effectively shrunk, and that the kaleidoscope has not stopped turning. It is a world, he argues, in which the key players must direct their nuclear thinking no longer to one but several nuclear adversaries; in which the action flows no longer between two actors, but in a daisy chain among three, even four players; in which the sources of instability are no longer confined to the core U.S.-Russian relationship, but have spread into the new regional nuclear subsystems; and in which the former and now endangered bilateral arms control framework from the earlier era no longer suffices, and an appropriate alternative remains remote.

A topic this complex, freighted with consequences this great, unsurprisingly stimulates controversy and dissonant perspectives both among experts and between countries. That is true of the essays in this collection, with none more so than the three essays assessing the Russian, Chinese, and U.S. approaches to the nuclear challenges these countries face. The authors note, however, where personal judgments differ and make an effort to engage one another.

Anya Loukianova Fink and Olga Oliker, in their essay “Russia’s Nuclear Weapons in a Multipolar World: Guarantors of Sovereignty, Great Power Status & More,” focus on Russia as still one of the two key actors in this more complicated nuclear setting. Starting from an overview of Russia’s assessment of the changing geopolitical context and its implications for national security, they turn their attention to the role Russian defense planners assign to nuclear weapons; their perspectives on how nuclear weapons fit into a broader framework of strategic deterrence; their views on Russia’s evolving nuclear doctrine, the first use of nuclear weapons, and limited nuclear options; the feasibility of escalation control; and the danger of inadvertent nuclear war. From this base, they shift to Russian perspectives on the nuclear programs and postures of the other key players, at the center of which is the United States. How Russian analysts judge the 2018 U.S. Nuclear Posture Review, the nature of the threat they see to Russia’s nuclear deterrent, and the U.S. technological advances that most worry them are discussed and evaluated. They conclude with thoughts about Russian perspectives on the factors

favoring or obstructing “global nuclear (dis)order” and Russian views on non-proliferation and arms control.

Li Bin offers his take in “The Revival of Nuclear Competition in an Altered Geopolitical Context: A Chinese Perspective.” He shares his views first on how U.S. and Russian positioning in the larger international setting has realigned the two countries (to a U.S. advantage and a Russian disadvantage), the power gap between the United States and China that will remain, the obstacles to major powers pursuing spheres of influence, and the fracturing of the nuclear universe as a growing number of states enter the nuclear club. What this means for China constitutes his second theme. He portrays a China whose economic and military power is growing rapidly along with the global reach of its economic and security interests, but that nonetheless has neither the hope nor intent to match either Russia or the United States as a nuclear superpower, and that is struggling to fashion a nuclear deterrent that it trusts measures up to the challenge posed by the United States. In this context, he explores those aspects of U.S. nuclear plans, potential new technologies, and strategy that most concern defense planners in his country. He then returns to the questions he raised at the outset: What aspects of major nuclear actors’ approaches to nuclear weapons are driven by security interests? What aspects are driven by a desire to augment a country’s political influence? And where between the two purposes can there be cooperation among states to enhance nuclear security, reduce the risks of inadvertent nuclear war, and contain the spread of nuclear weapons? The reader will doubtless be struck by how fundamentally different the Chinese perspective conveyed by Li Bin is from, in particular, that of the United States, including official U.S. assessments of the emerging challenge posed by China.

American responses to a changing nuclear security environment are described by Brad Roberts in his essay “On Adapting Nuclear Deterrence to Reduce Nuclear Risk.” He begins with a review of the ways in which U.S. presidential administrations since the end of the Cold War have sought to adapt deterrence to new challenges and reduce nuclear dangers and risks. The net result over more than two decades has been a decreased reliance on nuclear weapons in U.S. defense strategy, an increased reliance on non-nuclear means, including missile defense and non-nuclear strike, and a tailoring of U.S. deterrence strategies to reflect a more multipolar world and the emergence of new technologies of strategic consequence. The core of Roberts’s argument focuses on whether, in the current security environment, the United States can continue altering its approach to deterrence in ways intended to further reduce nuclear risk. He argues against steps favored by many, such as stepping down all U.S. and Russian intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles (SLBMs) from high-alert status, contending that the net effect would actually be to increase nuclear risk. He cautions against other changes that, in his view, would make nuclear deterrence unreliable in dealing with problems for which it remains relevant,

especially the problems of extended deterrence and assurance of U.S. allies. His analysis of these problems helps bring into focus the stark differences of opinion in Washington, Moscow, and Beijing over the actions and perceived intentions of one or both of the other two in the nuclear realm.

Part two of the issue grapples with the second key dimension of a new multipolar nuclear world: the fate of efforts to control nuclear weapons and manage the historically pivotal nuclear relationship between the United States and Russia. Linton Brooks – in “The End of Arms Control?” – weighs the all-too-realistic prospect that the last remaining strategic nuclear arms control treaty between the United States and Russia – New START, signed by President Obama and President Medvedev in 2009 – will not survive, and considers the potential consequences. He examines these from a number of angles: the impact on strategic stability from the loss of transparency and predictability provided by the treaty, the reduced constraint on pressures to keep step with Russia and the arms race tension this generates, the damage done to the nuclear nonproliferation regime by the seeming bad faith of Russia and the United States in their Article VI commitment to nuclear disarmament, and, in the United States, the erosion of political support for the current nuclear modernization program absent a concomitant effort to pursue arms control. He focuses particular attention on what steps the United States and Russia could take to mitigate the effects should New START be lost, grouped into five categories: measures to enhance transparency and predictability in the nuclear programs of the United States and Russia, secondary areas of potential security cooperation that could affect positively the nuclear relationship, joint U.S.-Russian actions to improve the context for nonproliferation efforts, informal bilateral understandings intended to preserve some of the treaty’s benefit, and unilateral U.S. actions that can have an indirect stabilizing effect, including leadership in pursuing strategic dialogue at various levels. Under each heading, Brooks offers specific ideas: some familiar but neglected, some rarely applied to the nuclear context, and others freshly designed for new challenges. In particular, he offers suggestions to prevent inadvertent escalation, an area in which treaty-based arms control has made only limited progress.

Arms control, in contrast to disarmament, should be thought of not as an end, but as a means to an end: a tool. Jon Wolfsthal takes this perspective in his answer to the question “Why Arms Control?” Wolfsthal argues that arms control can reduce the risks of nuclear use, crisis instability, and accidental or deliberate nuclear conflict; control the scope and shape of nuclear arms racing; and generate trust opening the way to security cooperation in other spheres. To support his argument, he points to several agreements reached between the United States and the Soviet Union during the Cold War. The 1972 Anti-Ballistic Missile Treaty, he notes, employed a mutually accepted concept serving as the base for strategic stability

and impeded a potentially dangerous and costly offensive-defensive arms race. The 1987 Intermediate Nuclear Force Treaty eliminated an entire class of nuclear weapons: weapons that posed the threat of a hasty resort to nuclear use because of the short warning they allowed decision-makers. The ill-fated 1993 START II agreement would have blocked the development of multiple independently targetable reentry vehicles (MIRVs), thus avoiding the heightened chance that in a crisis either side possessing these high-value targets would feel pressure to “use ’em or lose ’em.” While Wolfsthal makes the case for nuclear arms control, he is realistic about the scant likelihood of further or even sustained U.S.-Russian nuclear arms control treaties. On the contrary, he laments the loss of a common set of goals in pursuit of strategic stability: the prerequisite for achieving nuclear arms control agreements. Here, he is in accord with Roberts, though where Roberts places most of the blame on Russia, Wolfsthal assigns blame to both sides.

In “What History Can Teach,” James Cameron concludes this portion of the analysis by assessing the role that arms control played during the Cold War nuclear era. He centers his argument on the tension between the idealized goals of arms control held by its original theorists, like Thomas Schelling, and its actual subordination to the geopolitical and national security needs felt by political decision-makers at the time. He explores why, rather than giving priority to the goal of strategic stability based on mutually invulnerable second-strike forces, the arms control enterprise initially focused more on containing the emergence of further nuclear powers and shoring up U.S. extended-deterrence commitments. And then for largely political rather than strategic reasons, how it, in part, did settle on negotiating constraints on elements in each side’s forces that threatened strategic stability. Cameron finishes by reflecting on the extent to which the prospects for arms control and its possible future role in a multidimensional world of rising nuclear powers will echo the complex interplay of narrow nuclear calculations, larger geostrategic considerations, and political pressures characterizing the last century.

In the final section of the volume, the authors turn to three critical dimensions of the challenge posed by the multipolar world. The continuous advance of technology remains a critical dimension of the way the contemporary nuclear setting is shape-shifting. Rather than catalog the specific technologies involved, for which there is an existing literature, Christopher Chyba concentrates on developing a framework for understanding the impact of new technologies on the concept of strategic stability. In his essay “New Technologies & Strategic Stability,” he identifies several factors that determine how disruptive a new technology might be: the pace and ease with which the technology – whether a weapons system or an enabling technology – spreads among nuclear adversaries; the destructive capability of a technology and its implications for deterrence and defense;

and its impact on decision-making time, the accuracy of information available in the event, as well as the prospects for misjudgment and accidents. How each factor favors or inhibits strategic stability, he notes, depends on a constellation of more specific questions to which each factor gives rise. These need to be answered in context, including whether, from a comparative perspective, a technology's effects qualitatively or quantitatively differ from those of existing technology. Employing these metrics, Chyba then explores possible ways by which technological pathways destructive of strategic stability can be identified and possibly mitigated. To illustrate, he focuses this framework on three new technologies: hypersonic delivery vehicles, antisatellite weapons (ASAT) technologies, and artificial intelligence.

Among emerging technologies, none is more salient than the advance of cyberattack capabilities, including the prospect of integrating cyber warfare into the nuclear sphere. In his essay "Cyber Warfare & Inadvertent Escalation," James Acton makes the case that potential cyber threats to nuclear forces and their command, control, communication, and intelligence (C3I) systems create new escalation pathways that are qualitatively different from escalation risks generated by other sources. These pathways, he argues, result from six key differences between sophisticated cyber capabilities and other technologies. Cyber espionage opens a thoroughly more intrusive ability to monitor an opponent's nuclear forces and operations. Cyber tools offer an unprecedented means of manipulating an opponent's ability to accurately assess fast moving events. Cyber operations, however, generate what he characterizes as unanticipated collateral effects. Cyberattacks are easier to conceal and more difficult to trace than attacks by most other means. And in cyberspace, distinguishing between what may be offensive operations and what is simply espionage activity is particularly difficult, creating risks of responding to cyber espionage as if it were an attack. He then draws a distinction between deliberate cyber interference and nondeliberate or inadvertent interference (the result of misperception or accident), detailing the many reasons one or the other could occur. While recognizing that cyber capabilities by their nature are much more difficult to manage or limit through cooperative measures than other capabilities, Acton concludes with suggestions for how states could reduce the unique hazards emerging from increased cyber capabilities.

One of the major trends in this new nuclear age is the growing momentum behind the movement in favor of a treaty banning nuclear weapons, now extending to 122 state signatories. Harald Müller and Carmen Wunderlich, in their contribution "Nuclear Disarmament without the Nuclear-Weapon States: The Nuclear Weapon Ban Treaty," examine this phenomenon as a new normative dimension of efforts to come to terms with the nuclear challenge. They cast the analysis in the broader context of four sets of norms that have figured in the management of nuclear weapons: nonproliferation, disarmament, constraints on use, and political

restraint. They begin with an exploration of the fundamental nature of such norms: their character, their potential effects, and the countervailing impulses they generate. They next trace the impact that each set of norms has had or could have on the behavior of nuclear actors, followed by the kinds of and reasons for resistance to them. They argue that norms do not stand alone but often form a network of intended or unintended interacting effects. At the heart of the agitation surrounding the ban treaty, however, is another dichotomy between ends that meet the concerns of a global community, and means that often reflect the concerns of particular states. Müller and Wunderlich, after weighing the potential impact of the ban treaty, go on to consider what might be done to find common approaches to reduce nuclear dangers that would also soften the divide that separates nuclear-weapon-possessing states from the majority of non-nuclear-weapon states.

The section concludes with two authors tasked with imagining a future without treaty-based arms control and what paths instead could manage an increasingly complex, multidimensional nuclear world. James Timbie, in “A Way Forward,” attacks the challenge by setting out what nuclear-weapon states could do, short of treaties, to enhance the resilience of their societies and military establishments, to strengthen deterrence, and to reduce the risk of unintended conflict through cooperative and unilateral measures. In the first category, he suggests increasing the resilience of space-enabled communications and surveillance and navigations systems, as well as protecting nuclear forces and their command and control systems from cyberattack. On the deterrence front, he explores areas – for example, cyber threats and threats to space assets – in which existing theory is inadequate or requires rethinking. The majority of his essay develops at length a wide spectrum of cooperative measures along multiple dimensions that would add safety and stability to an evolving and uncertain nuclear world. These start with a variety of unilateral and bilateral commitments affecting strategic and nonstrategic nuclear forces, extend to steps preserving transparency and protecting early warning, and conclude with a rich array of measures to better manage the risks associated with missile defense, space, cyber, and long-range conventional systems. He argues that cooperation on such a broad package of measures can be negotiated given a serious effort, since it could address the full range of concerns expressed by the United States and Russia. His final recommendations are for improved mechanisms of communication between nuclear adversaries; a readiness to think longer and harder about the ramifications of new technologies, such as artificial intelligence, when applied to the nuclear realm; and an emphasis on research and education to prepare policy-makers for the complex decisions that they will need to make “in uncharted territory.”

In her essay “Life beyond Arms Control: Moving toward a Global Regime of Nuclear Restraint & Responsibility,” Nina Tannenwald takes a somewhat

different approach to ways and means to reduce nuclear dangers outside the frame of treaty-based reductions. What steps – formal or informal, unilateral, bilateral, or multilateral – might leaders consider? And, in the absence of arms control, what norms might be substituted? She argues that nuclear-armed states should move toward a global regime characterized by the norm of nuclear “restraint and responsibility.” Its objective would be the same as that of traditional arms control: to reduce threats, provide predictability, foster transparency, avoid nuclear use, and strengthen nuclear restraint. How could this global regime be pursued, other than through legally binding, treaty-based efforts? She finds lessons in past nonbinding political agreements, informal arrangements, and reciprocal unilateral commitments arranged between the Soviet Union and the United States. Some were simply parallel or joint declaratory initiatives, others coordinated unilateral actions, and still others forms of practical cooperation, such as the 1987 Nuclear Risk Reduction Centers Agreement. Using these examples, she proposes a range of ideas along the same lines that are nonetheless adapted to a nuclear world that differs considerably from its predecessor. Key to her analysis, she argues that in the present political environment, the pressures generated by civil society and popular movements will be essential if the more difficult recommendations are to stand a chance.

In the conclusion, we draw from the essays’ major themes and highlight the central points made by the authors. We also identify areas of common agreement among them as well as points of divergence. And, in a last step, we draw from each perspective in making our own recommendations for managing the challenges of this complex and unfamiliar multipolar nuclear world.

ABOUT THE AUTHORS

Robert Legvold, a Fellow of the American Academy since 2005, is the Marshall D. Shulman Professor Emeritus at Columbia University. He is Cochair of the “Meeting the Challenges of the New Nuclear Age” project at the American Academy, for which he wrote the research papers “Contemplating Strategic Stability in a Multipolar Nuclear World” (2019) and “Meeting the Challenges of the New Nuclear Age: Nuclear Weapons in a Changing Global Order” (with Steven E. Miller and Lawrence Freedman, 2019). His most recent book is *Return to Cold War* (2016).

Christopher F. Chyba is Professor of Astrophysical Sciences and International Affairs at Princeton University. He is Cochair of the “Meeting the Challenges of the New Nuclear Age” project at the American Academy, and has previously served on the staffs of the National Security Council and the Office of Science and Technology Policy, and as a member of the President’s Council of Advisors on Science and Technology.