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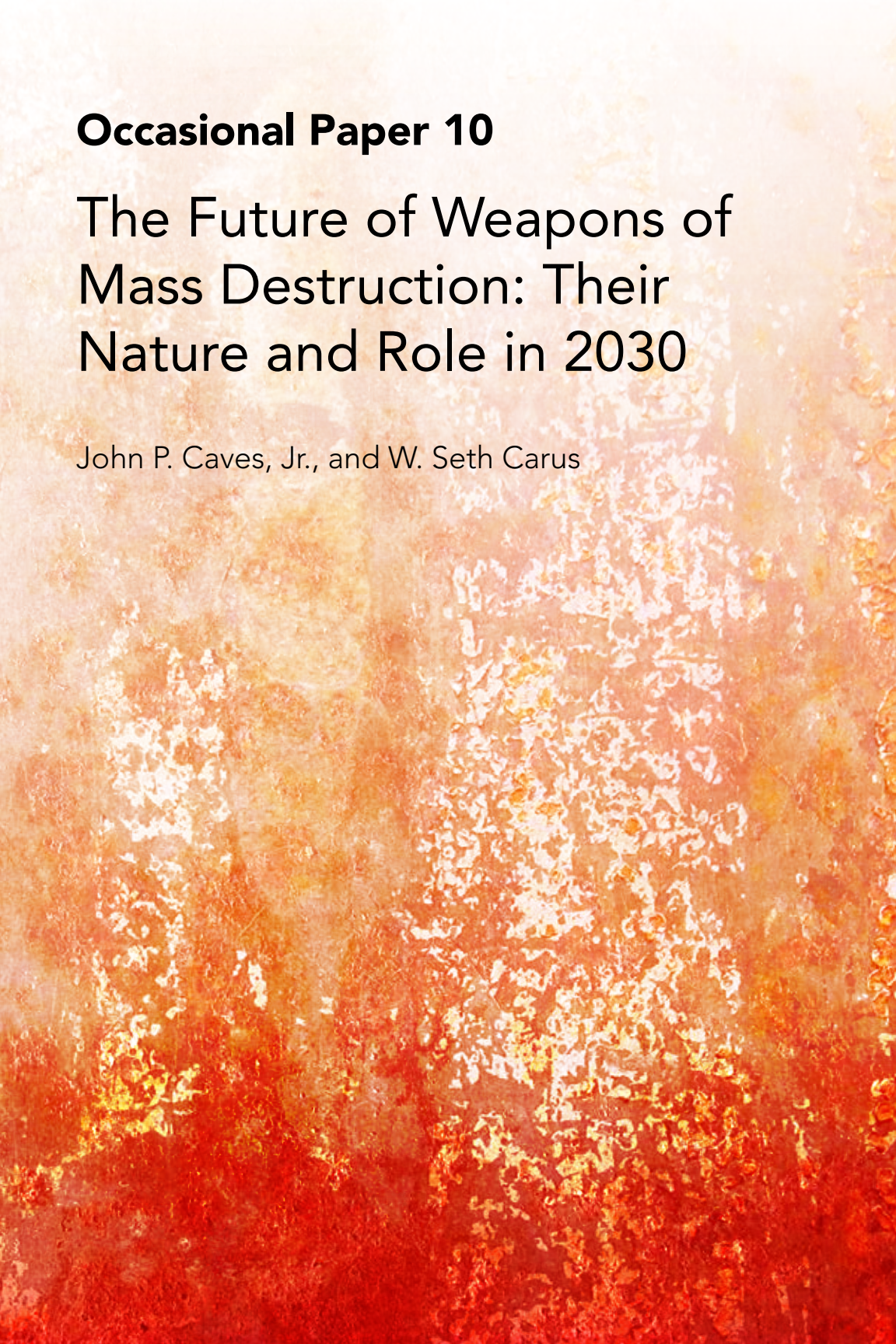
The Future of Weapons of Mass Destruction: Their Nature and Role in 2030

John P. Caves, Jr., and W. Seth Carus



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Since its inception in 1994, the Center for the Study of Weapons of Mass Destruction (WMD Center) has been at the forefront of research on the implications of weapons of mass destruction for U.S. security. Originally focusing on threats to the military, the WMD Center now also applies its expertise and body of research to the challenges of homeland security. The Center's mandate includes research, education, and outreach. Research focuses on understanding the security challenges posed by WMD and on fashioning effective responses thereto. The Chairman of the Joint Chiefs of Staff has designated the Center as the focal point for WMD education in the joint professional military education system. Education programs, including its courses on countering WMD and consequence management, enhance awareness in the next generation of military and civilian leaders of the WMD threat as it relates to defense and homeland security policy, programs, technology, and operations. As a part of its broad outreach efforts, the WMD Center hosts annual symposia on key issues bringing together leaders and experts from the government and private sectors. Visit the center online at wmdcenter.dodlive.mil.

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Foreword

In 2011, the Center for the Study of Weapons of Mass Destruction launched a project to envision the future of weapons of mass destruction (WMD). It chose the year 2030 as its time horizon. During the first year, we conducted a series of roundtable discussions with experts on global trends in political-military and technological developments. These discussions had a broad range and were not limited to WMD matters. During the second year, we established several working groups to focus on the WMD implications of future trends. Science and technology was the principal remit for the first group, geopolitics for the second, and military matters for the third, but all three groups concurrently considered the panoply of developments that could impact the future of WMD. While there was a great deal of commonality among each group's findings, differences also emerged. As there can be no one definitive forecast of the future, but at best only educated guesses, the WMD Center chose to publish more than one set of findings rather than to produce a single integrated report. The Center thus hopes to enrich the larger debate about the future of WMD and to afford U.S. policymakers multiple perspectives to consider as they decide where to steer U.S. efforts to counter tomorrow's WMD dangers.

John Caves and Seth Carus authored one set of findings. Mr. Caves co-chaired the project's working group whose principal remit was geopolitics, and Dr. Carus was the co-lead for the overall project. Their paper herein principally considers how the intersection of geopolitical and technological trends may shape the nature and role of WMD in 2030. Forrest Waller authored another set of findings. Mr. Waller led the project's working group whose principal remit was science and technology. Fittingly, Mr. Waller's forthcoming paper is first and foremost an examination of how science and technology trends may affect WMD by 2030. Both papers offer recommendations for U.S. policymakers in preparing for the envisioned WMD futures.

Dr. Carus, Mr. Caves, and Mr. Waller benefited greatly from the insights and support of many others, and particularly our colleagues at the WMD Center. I am privileged to direct a center staffed with such outstanding individuals.

—Dr. John F. Reichart
Senior Director
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Acknowledgments

While the authors are solely responsible for the final content of their respective papers, they were able to reach their findings only as the result of the time and expertise freely availed to them by many knowledgeable individuals and organizations. Foremost among them are their colleagues in the Center for the Study of Weapons of Mass Destruction, who contributed to the development of this paper and participated in the center's larger project on the future of WMD. Of particular note are Dr. John Reichart, director of the WMD Center; Mr. Robert Peters, co-lead for the overall project and co-chair of the working group on military matters; Mr. Brendan Melley, co-chair of the working group on geopolitics; and Dr. John Mark Mattox, co-chair of the working group on military matters. Also of note are Mr. Paul Bernstein, Mr. Richard Love, Mr. Charles Lutes, Dr. Shane Smith, Ms. Lorena Bedford, Mr. Kenneth Rapuano, and Ambassador Linton Brooks.

Among the many individuals from outside the Center who helped make this project possible are leaders and experts of the Pacific Northwest National Laboratory, Sandia National Laboratories, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Air Force Research Laboratory in Albuquerque, the Center for International Security and Cooperation at Stanford University, Naval Postgraduate School, Monterrey Institute for International Studies, Center for Science, Technology, and Policy at the University of New Mexico, Central Intelligence Agency, and the Office of the Director of National Intelligence.

We also are indebted to the many current and former U.S. Government officials and experts who participated in one or more of the center's several workshops for the project. We further benefited from a highly productive exchange of ideas on the future of WMD during a workshop with knowledgeable representatives from the United Kingdom Ministry of Defence and the British Embassy in Washington, DC.

Executive Summary

The longstanding efforts of the international community writ large to exclude weapons of mass destruction (WMD) from international competition and conflict could be undermined in 2030. The proliferation of these weapons is likely to be harder to prevent and thus potentially more prevalent. Nuclear weapons are likely to play a more significant role in the international security environment, and current constraints on the proliferation and use of chemical and biological weapons could diminish. There will be greater scope for WMD terrorism, though it is not possible to predict the frequency or severity of any future employment of WMD. New forms of WMD—beyond chemical, biological, radiological, and nuclear weapons—are unlikely to emerge by 2030, but cyber weapons will probably be capable of inflicting such widespread disruption that the United States may become as reliant on the threat to impose unacceptable costs to deter large-scale cyber attack as it currently is to deter the use of WMD. The definition of *weapons of mass destruction* will remain uncertain and controversial in 2030, and its value as an analytic category will be increasingly open to question.

These conclusions about the future of WMD derive from judgments about relevant technological and geopolitical developments out to 2030. Technological developments will shape what WMD capabilities will be achievable in that timeframe while geopolitical developments will shape motivations to acquire and use WMD.

Technologically, by 2030, there will be lower obstacles to the covert development of nuclear weapons and to the development of more sophisticated nuclear weapons. Chemical and biological weapons (CBW) are likely to be 1) more accessible to both state and nonstate actors due to lower barriers to the acquisition of current and currently emerging CBW technologies; 2) more capable, particularly in terms of their ability to defeat current or currently emerging defensive countermeasures; 3) more discriminate; that is, more precisely targeted and/or more reliably low- or nonlethal; and 4) harder to attribute (utilizing hitherto unknown agents and/or delivery mechanisms) than the traditional forms known today. No major new technological developments regarding radiological weapons are foreseen.

Geopolitically, the United States will remain the world's most powerful country through 2030 but will be less dominant in an increasingly multipolar international system. Nonstate groups, potentially including terrorists, will grow in capabilities and importance. Sources of international conflict will remain and could intensify, and the risks for armed conflict, both inter- and intrastate, will grow. The "battle of narratives" will be an increasingly important part of armed conflict.

Taken together, these developments and characteristics point to a world that in 2030 will be more prosperous, technologically capable, and connected, but one whose international relations will be more competitive and uncertain. The world's gains will not be distributed equally, and its constituents will be more keenly aware of the inequalities. While the United States should remain the single most powerful actor, it will not be hegemonic. The share of global power held by Washington and its Western allies will have declined significantly. Pax Americana will be fading, but a new order policed by a similarly dominant power will not yet be visible much less in place. The commitment of the rising powers to the pillars of Pax Americana, including its nonproliferation norms and regimes, will be tested.

More states are likely to cleave to or seek out the perceived security of nuclear weapons in this more uncertain environment, and some may test the political and military utility of new biological and chemical weapons capabilities made possible by technological developments, especially in the life sciences. There will be greater scope for WMD terrorism. Of particular concern will be how the diffusion of WMD technologies will increase the capacity of small groups and even lone actors, whose motivations and actions are inherently less subject to prediction and control, to acquire and employ the technologies of mass destruction even if done inadvertently.

How should the United States prepare for such a future? Since no future is preordained, it first must devote attention to shoring up the means by which it has been able to mitigate the spread and use of WMD to date: 1) sustaining its will and ability to meet its extended deterrence commitments and the benefitting allies' perception thereof; 2) universalizing and deepening the international commitment to the principles, tenets, and implementation of the WMD nonproliferation norms and regimes; and 3) identifying, acquiring, and deploying the means

to detect, track, and monitor the emerging technical means by which WMD can be developed and concealed.

Whatever success the United States and like-minded nations can achieve in the above three areas should mitigate the anticipated future WMD challenges but should not be relied on to wholly preclude them. Therefore, the United States must also prepare for the above-described WMD circumstances of 2030. Foremost is recognizing that America and other countries are likely to become more reliant on deterrence and less on prevention to counter the dangers of a more WMD-proliferated world. This will put a premium on investing in the key attributes of effective deterrence: an unambiguous capacity to impose unacceptable costs on WMD-armed adversaries; the ability to defeat limited WMD attacks, particularly through missile defense and homeland security measures; the ability to attribute WMD attacks; and the effective strategic communication of our deterrence capabilities and will to employ them.

Nuclear weapons will figure prominently in the deterrence strategies of a number of states in 2030. It will be imperative for the United States to maintain a robust, reliable, and credible nuclear deterrent force in that environment. Accordingly, Washington should preferentially fund the modernization of its nuclear arsenal and supporting infrastructure to ensure a credible and effective nuclear deterrent to 2030 and beyond. Deterring and responding to adversary nuclear weapons threats and potential employment must also figure more prominently and systemically in U.S. military plans, as well as in the education of U.S. military and civilian national security leaders, so the United States is better prepared to manage escalation challenges amidst increasing nuclear risks.

Washington further needs to anticipate and prepare for the possible reemergence of chemical and biological warfare as novel and more effective forms of these weapons emerge from rapid advances in the life sciences over the next two decades. Washington should assume that it will encounter the employment of hitherto unknown chemical and biological agents in military and civilian environments, and will need to develop a mindset, approaches, and capabilities for recognizing and responding to unknown agent attacks. It also should continue to invest in broad-spectrum defensive countermeasures that are better able to recognize,

protect against, and treat a wide range of chemical and biological threats. Furthermore, it should be prepared to alter its negative security assurances with regard to the employment of U.S. nuclear weapons to respond to a heightened biological or chemical weapons threat from nonnuclear weapons states.

With specific regard to WMD terrorism, the greater accessibility that terrorists should have to current and currently-emerging WMD technologies, and particularly those relating to CBW, will require the United States to maintain intense and multifaceted efforts to dissuade such entities from seeking WMD and prevent them from employing them. While it is not known what has most accounted for the paucity of terrorist use of even cruder forms of WMD to date, or at least employment that has resulted in mass destruction, the combination of strong international norms, intense law enforcement and military pressure, and improved defenses likely have all contributed to this desired outcome. It is only prudent to sustain and, where possible, intensify this multitude of deliberate obstacles to terrorist acquisition and employment of WMD.

While the future cyber threat may foster consideration of strategic responses comparable to those made to the WMD threat, it would seem inappropriate and possibly disadvantageous to the United States to apply the WMD moniker to cyber weapons at this time. WMD have been given special priority for elimination or control. Several treaties also place specific limitations on their use, and making cyber weapons a form of WMD would automatically make those provisions apply. Until the United States better understands whether it wants to develop an international regime constraining cyberspace or to maximize its flexibility to utilize a capability in which it is the acknowledged world leader, there are no advantages to treating cyber weapons as WMD.

Introduction

This paper explores the possible nature and role of weapons of mass destruction (WMD) in the 2030 timeframe. That is, it endeavors to describe what will constitute WMD in that timeframe and why and to what extent actors may pursue, acquire, and even employ such weapons. It is a product of the Center for the Study of Weapons of Mass Destruction's Project on the Future of WMD, an effort that began in late 2010 and involved consultations with a range of government officials and other experts as well as a literature review on relevant technological and geopolitical trends.

The Center undertook this study keenly appreciative of the limitations inherent to any effort to project future developments, particularly beyond 5 years. We nonetheless hoped that thoughtful consideration about what might transpire with WMD over the longer term could usefully inform nearer term U.S. Government plans and investments for countering WMD that might have longer term implications.

We understand that the role of WMD will be shaped to a greater or lesser extent by political, military, economic, and social forces that are themselves difficult to predict. In addition, we realize that the policies adopted and the actions taken by the U.S. Government will affect the shape of the future both for the security environment and for WMD in particular. For these reasons, we offer a picture of the future security environment painted with broad-brush strokes and generally avoid associating wide-reaching developments with specific foreign actors or circumstances.

However, we are sensitive to the need for prudence; therefore, we focus on plausible developments that could pose serious challenges. Thus, for example, we consider it both more likely and prudent to assume that China, an emerging great power, will continue its rise, increasing the costs and risks to the United States of sustaining its current international position and security commitments. Fewer regrets are likely to attend U.S. international security interests if the Nation prepares for this future rather than for a less challenging alternative. Indeed, accepting that some dangers are more likely may help stimulate U.S. leaders to take actions to

sustain U.S. national power over the longer term, such as measures to stimulate economic growth and manage the deficit.

Envisioning the future of WMD entails challenges beyond only those associated with projecting future developments generally. Because WMD have so seldom been employed, and countries that possess such weapons tend to be secretive about these capabilities and their intentions regarding them, there is a paucity of factual information from which to extrapolate on why countries will seek WMD and how they are likely to use them. Perhaps the most important and challenging question today is why these weapons have so seldom been employed, particularly those chemical, biological, and radiological weapons that are considered accessible to the violent extremists who are believed to be the most likely to employ them. Theories abound, but none can be proven; hence judgments about the future of WMD tend to be more intuitive than empirical.

Our judgments about the nature and role of WMD in the 2030 timeframe are developed in five sections. The first offers baseline observations about WMD in 2014. The second considers how technological trends could shape the nature and accessibility of WMD in 2030. The third discusses geopolitical trends that could influence how state and nonstate actors will view WMD in 2030. The fourth makes judgments about the role of WMD in 2030 in light of the foregoing discussion of technological and geopolitical developments. The final section offers considerations for U.S. policy in preparing for the WMD challenge of 2030 that we envision.

WMD in 2014

This section offers observations about WMD today, providing a baseline for our exploration of potential changes during the coming two decades.

For the purposes of this paper, *weapons of mass destruction* are defined as chemical, biological, radiological, and nuclear (CBRN) weapons. While it may seem unnecessary to make this observation, in actuality there are a variety of definitions of WMD in current use.[1] Here we chose to adopt the official United Nations (UN) definition, which is used for disarmament, diplomacy, and arms control treaties:

> *Atomic explosive weapons, radioactive material weapons, lethal chemical and biological weapons and any weapons developed in the future which might have characteristics comparable in destructive effect to those of the atomic bomb or other weapons mentioned above.*[2]

As a practical matter, the UN definition is interpreted as applying to all CBRN weapons even if they are not necessarily lethal. Significantly, this definition originated in the late 1940s to support the UN disarmament agenda by identifying weapons categories that deserved special consideration for elimination or control. So far, the international community has rejected attempts to expand WMD beyond CBRN weapons. Mindful that the UN definition explicitly allows for the possibility of entirely new forms of WMD emerging in the future—that is, other than CBRN—we address the prospects for that occurring by 2030 later in this paper.

There are several problems with the UN definition. Some types of CBR weapons can be employed to inflict discrete effects while conventional weapons can be employed in ways that are massively destructive. As a result, the UN definition includes weapons that may be incapable of causing either mass destruction or mass fatalities, while excluding some that actually have caused mass death and destruction. Thus, radiological weapons are now seen as the most likely to cause relatively localized effects. Many biological and chemical agents can be used in highly discriminate ways, including assassinations, and some chemical and biological agents such as foot and mouth disease may be useful mainly for disruption. Moreover, different types of WMD can have different political-military effects. For example, as discussed later, we believe that CBR weapons do not have the same deterrent effect as nuclear weapons. Finally, conventional weapons can be employed en masse to generate effects comparable to those of nuclear weapons, as evident from the impact of conventional bombing during World War II. It is also telling that more people were killed in the Rwanda genocide by simple weapons than have died from all uses of WMD in war.[3]

Alternative definitions are no more satisfactory. Some add high explosives (in the United States, this occurs mainly in the law enforcement community),

which impractically would treat virtually all weapons of war used by modern militaries as WMD. Others count only those types of CBRN weapons that cross a certain vaguely-defined threshold of "mass destruction" or lethality, but there is no widely accepted definition of what constitutes mass destruction. Another approach would define WMD as weapons that are especially abhorrent and thus subjected to exceptional controls or outright prohibition. Yet while this is the case for CBRN weapons, for much of the international community it also is true for other types of weapons, such as antipersonnel landmines and cluster munitions.

The international community writ large seeks to exclude WMD from international competition and conflict. Only the five original nuclear weapons states are authorized under international law to possess nuclear weapons, and they are obligated by Article VI of the 1970 Nuclear Nonproliferation Treaty (NPT) to work toward the abolition of all nuclear weapons in the context of general and complete disarmament. Renewed attention and commitment to the achievement of that goal, including by the Obama administration, has followed Henry Kissinger, Sam Nunn, William Perry, and George Shultz's articulation of a vision for the eventual elimination of all nuclear weapons in a January 2007 *Wall Street Journal* editorial.[4] Biological and chemical weapons are prohibited to all States Parties by the 1975 Biological and Toxins Weapons Convention (BWC) and the 1997 Chemical Weapons Convention (CWC), respectively. There is, however, an exception in the CWC for nonlethal chemical agents used for law enforcement purposes that may loom larger in the future. Interestingly, no comparable treaty exists to prohibit radiological weapons, although there have been efforts to negotiate one.[5]

The achievement of these instruments' goals is supported by other international nonproliferation agreements, regimes, programs, and initiatives, such as a number of regional nuclear weapons-free zone treaties, the Nuclear Suppliers Group and Australia Group, cooperative threat reduction programs, the Geneva Protocol, the Outer Space and Seabed treaties, and the Proliferation Security Initiative, as well as by ongoing efforts to extend the nuclear weapons control regime by bringing the Comprehensive Nuclear Test Ban Treaty into force and negotiating a Fissile Material Cutoff Treaty.[6] Indeed, it could be argued that the international community has effectively marginalized the military role of

chemical and biological weapons, and only nuclear weapons are seen to retain utility as a deterrent.

WMD proliferation is currently a limited problem set. Almost all states belong to, and are deemed compliant with, the major nonproliferation treaties. In 2013, Syria, a longstanding CWC holdout, joined the convention and agreed to a detailed plan for the elimination of its declared CW stocks and capabilities. In January 2014, Libya completed the elimination of its declared CW program.[7] These were important recent gains for the cause of WMD nonproliferation.

A few countries, however, remain outside one or more of the aforementioned treaties that proscribe WMD. India, Israel, and Pakistan have never accepted the NPT, and North Korea withdrew in 2003. Egypt, North Korea, South Sudan, and Angola have never joined the CWC, while Israel and Burma have signed but not ratified it. A somewhat larger number of states, mostly in Africa but including Israel, have never joined the BWC, and others including Egypt and Syria have signed but not ratified it. In addition, a few of the States Parties to one or more of these nonproliferation agreements are suspected of violating their obligations under them. Iran figures most prominently among them, but the United States has questions about aspects of Russia's, China's, and a few others' compliance with one or more of the treaties.[8] India and Pakistan, two of the four nuclear weapons states outside the NPT, are also a major concern because many think that conflict between these two rivals has the most potential to lead to an actual nuclear weapons exchange. Further, there is concern about the potential for some or all of Pakistan's nuclear weapons to fall under the control of radical Islamists active in the country either through an illicit acquisition or an assumption of state power.

There have been two major adverse proliferation developments in recent years: North Korea's self-proclaimed acquisition of nuclear weapons, supported by three nuclear device tests; and Iran's suspected pursuit of nuclear weapons, supported inter alia by its refusal to heed the UN Security Council Resolutions that it suspend uranium enrichment and demonstrate that its nuclear program is strictly for peaceful purposes. While North Korea's nuclear weapons program remains largely unconstrained, negotiations among Iran and the P5+1 states (China, France, Germany, Russia, the United Kingdom, and the United States) produced

an interim agreement in November 2013 to freeze most aspects of Iran's nuclear program. This agreement is to be in effect for 6 months pending the negotiation of a permanent accord that would align Iran's nuclear endeavors with international expectations.

Fears that these adverse proliferation developments will spur regional rivals, many of them U.S. allies, to seek their own nuclear weapons (which some have called a "nuclear cascade") have not been borne out to date. Similar fears during the 1960s went largely unrealized. Whereas in 1963 President John Kennedy foresaw the possibility of 15 to 20 new nuclear weapons states within a decade,[9] the actual proliferation pattern since has been more like one per decade. That the worst fears of nuclear proliferation then did not materialize had much to do with concerted efforts by the United States and other nations, including the negotiation and entry into force of the NPT and extended U.S. deterrence security commitments to major allies.[10] Thus the current set of states of serious WMD proliferation concern is quite small, with Iran and North Korea at the forefront.

WMD are rarely employed. There has been no confirmed employment of radiological weapons.[11] There has been no employment of a nuclear weapon since their initial use by the United States against Japan in 1945. The last confirmed state employment of biological weapons (and their only confirmed large-scale employment) was by Japan against China during World War II. Iraq's large-scale use of chemical weapons against Iranian forces and its own population during the 1980s was the last confirmed state use of these weapons prior to the CWC, and it provided essential impetus to the negotiations that resulted in that international convention. With the important exception of Syria's CW use during its civil war, the only known instances of employment of biological and chemical weapons since the BWC and CWC came into force in 1972 and 1997, respectively, have been by violent nonstate actors.

The most significant nonstate actor employment of WMD was by the apocalyptic Aum Shinrikyo in 1994. The cult made a major, though largely unsuccessful, investment in biological and chemical weapons development and perpetrated several attacks, two of which featured the chemical agent sarin and resulted in some 20 fatalities.[12] A decade earlier, another cult, the Rajneeshees, disseminated salmonella

in fast food restaurant salad bars in Oregon, sickening about 750 people but killing no one.[13] A lone U.S. scientist, Bruce Ivins, was determined to have mailed anthrax-filled letters in late 2001 and early 2002 that caused five deaths but had much broader disruptive effects.[14] In 2006–2007, the terrorist group al Qaeda in Iraq employed chlorine tanks with high explosives that had little effect attributable to the chlorine in that country.[15] In recent years, there have been reports of insurgent or terrorist chemical agent use against girls' schools in Afghanistan, possibly involving pesticides, but with no fatalities.[16] In 2013, a U.S. individual was arrested for mailing ricin with letters to a U.S. Senator and the President, but causing no casualties.[17] Compared to the use of conventional weapons over the last few decades, these instances of WMD employment are rare and, contrary to the literal meaning of the term, not particularly destructive. Indeed, in some years the number of people killed through use of small arms and other conventional weapons can exceed the total killed by WMD in the previous hundred years.[18]

Syria's CW employment in 2012–2013 broke from this post-CWC pattern in that it involved state use and large-scale casualties. It initially stoked fears of the dangerous erosion of the international norm against CW use and of the CW nonproliferation regime. Those initial concerns were fueled by reports of Syria's small-scale employment of chemical weapons against rebels and civilians on its own territory on multiple occasions from December 2012 on and the muted international reaction.[19] The United States was particularly cautious about concluding that the Syrian regime had used chemical weapons, and, once it did, about committing to any punitive action against the regime.

Syria's subsequent CW use in August 2013 in the vicinity of the Syrian village of Ghouta left little room for such qualification. Those attacks allegedly killed more than 1,500 people,[20] and investigations by Human Rights Watch[21] and the United Nations[22] directly or indirectly implicated the Syrian regime. The United States, France, and the United Kingdom each threatened military retaliation, though the likelihood of strikes diminished after the UK parliament voted against military action and President Obama thereafter decided to seek his own prior legislative authorization. Perhaps more significant to Damascus, press accounts indicated that the Syrian leadership also received complaints about the CW use

from its three most important supporters, Hizballah, Iran, and Russia.[23] Moscow ultimately preempted Western military retaliation by proposing that Syria surrender its chemical weapons,[24] a proposal subsequently accepted by Syria, the United States, and the larger international community.

Syria's decision to join the CWC and eliminate its declared CW assets turned what had appeared to be a serious setback for the cause of prohibiting CW use and proliferation into an apparent victory.[25] The stronger international reaction, including the prospect, however uncertain, of Western military retaliation, undoubtedly contributed to that favorable turn of events. But Syria's decision may have been motivated less by fear than by opportunity. Recognizing that the United States and its major European allies were more likely to take direct action against Syria over CW than over the course of its civil conflict, Damascus may have concluded that abandoning its CW was a price worth paying to ensure a freer hand to prosecute its war, where it was beginning to gain the upper hand.[26]

Nuclear weapons are useful to states mainly for deterrence and prestige. Nuclear weapons have unrivaled utility for deterring serious threats to vital interests that arise from their demonstrated capacity to inflict extraordinary levels of destruction against which there is no effective defense (at least against the prompt effects of a nuclear weapon once detonated). No state possessing nuclear weapons has suffered a major invasion or other direct external threat to its regime survival, with the possible exception of Israel during the 1967 and 1973 Arab-Israeli Wars.[27]

Those possessing nuclear weapons justify and utilize them as deterrents, albeit by varying approaches. For example, China, which espouses a no-first-nuclear-use doctrine and fields a much smaller nuclear force than Russia or the United States, relies on the threat of retaliatory strikes to deter nuclear attacks upon it.[28] Russia and Pakistan, each facing one or more conventionally superior rivals, rely on their nuclear forces to deter large-scale conventional attack as well as nuclear strikes. They accordingly reserve their right to first use and are prepared (or preparing) to use tactical nuclear weapons to defeat superior conventional forces, as well as longer-range nuclear weapons to strike adversaries' strategic assets.[29] During the Cold War, Washington relied on a similar approach to deter what it feared were

superior Soviet conventional forces poised to invade Western Europe. Though the United States currently has no conventional military peer, it still reserves the right of first use of its nuclear weapons and accords to those weapons the mission of deterring a wider range of adversary aggression than just nuclear weapon use, but within a narrower range of contingencies and with the explicit goal of further reducing its reliance on nuclear weapons.[30]

While utilized and apparently effective for deterrence, nuclear weapons since 1945 generally have not proven directly useful for coercion—that is, compelling another to take an action it does not want to take as opposed to deterring it from taking an action to which it might otherwise be inclined.[31] No nuclear weapon has been employed since Hiroshima and Nagasaki. Threats to employ nuclear weapons except in the defense of the possessor's most vital interests have been rare, and, when issued, have not been sufficiently credible to compel desired behavior. Of late, Russia's nuclear saber rattling against Central European states negotiating with the United States to host U.S. missile defense assets did not dissuade those states from agreeing to host those assets. North Korea's constant torrent of blood-curdling threats against South Korea has become no more credible or compelling since the North tested its nuclear devices.

It is easier to understand why nuclear weapons have not been directly useful for coercion in those situations involving opponents who are each nuclear-armed or credibly enjoy the protection of a nuclear-armed state than in situations where only one side wields them. Nuclear weapons states have been careful to limit their confrontations with other nuclear-armed states or their protected allies lest such confrontations escalate to devastating nuclear exchanges. This has been true even in those few cases where nuclear-armed or protected states came to conventional blows, including China's intervention in the Korean War (where China was perceived as enjoying the protection of the nuclear-armed Soviet Union), the 1965 Sino-Soviet border clashes, and the 1999 Indo-Pakistani Kargil conflict. It may be notable that each of those cases occurred within a few years of one or both of the antagonists' or their protectors' acquisition of nuclear weapons, perhaps reflecting an immature appreciation of the risks of nuclear war that would change with more experience.

The 1962 Cuban Missile Crisis helps illustrate why nuclear weapons have not been useful for coercion since 1945. Moscow's placement of nuclear-armed missiles in Cuba ultimately led to Washington's agreement to withdraw its nuclear-armed Jupiter missiles from Turkey and pledge not to invade Cuba in exchange for the Soviet withdrawal of its missiles. Yet the manner in which the Soviet nuclear gambit was exposed and perceptions of the Soviet withdrawal of its missiles—under the threat of U.S. military action implicitly backed by nuclear force—made the Soviets look like the bigger loser in Cuba. Moreover, the crisis became a testament to the unpalatable risks of nuclear brinksmanship and fostered more careful interactions between the two superpowers going forward as well as their engagement in nuclear arms control.

But why have nuclear-armed states not found their nuclear weapons useful for coercing those who lack the protection of these weapons? That may be best explained in terms of the strong international norm[32] that developed against the employment of nuclear weapons. That norm raised the political costs of employing these weapons for any purpose other than in defense of a state's most vital interests to a prohibitive level. The United States played a central role in developing this norm by refraining from exploiting its initial nuclear weapons monopoly and subsequent superiority; it thus did not employ nuclear weapons in its early Cold War conflicts and confrontations, though some advocated their employment, for example, during the Korean War.[33] Instead, Washington accorded these weapons a special status that helped shape global perceptions and practices. This norm is now reflected in the negative security assurances offered by the major nuclear weapons states[34] and has likely helped to protect nonnuclear weapons states that are not aligned with a nuclear weapons state from actual nuclear attacks or credible, coercive threats of such attacks. There is no assurance going forward that the norm against nuclear aggression will remain as influential across the board or that some nuclear-armed actor will not prove exceptionally insensitive to it, but it seems to have been influential to date.

Nuclear weapons also confer prestige in the view of some aspirant states. As the greatest powers since the advent of nuclear weapons have possessed these ultimate instruments of mass destruction, other states aspiring to great power status

have felt the need for them. That apparently contributed to the United Kingdom, France, China, and India acquiring such weapons. North Korea, which claims to possess nuclear weapons, and Iran, which many suspect of pursuing them, often boast of their nuclear pursuits as hallmarks of technological prowess and befitting the international status they seek (for Iran, becoming a regional great power; for North Korea, being taken seriously by the great powers).

Chemical and biological weapons have limited utility for deterrence, and their perceived utility for warfighting has declined since the end of the Cold War. In the past, some countries relied on chemical and biological weapons (CBW) as a component of their deterrent posture. For those lacking the resources and expertise to develop nuclear weapons in the near term, such as Syria and Saddam Hussein's Iraq, CBW had utility as a "poor man's atomic bomb." Even for some Western states that possessed nuclear weapons, such as the United States and United Kingdom, CBW were viewed as in-kind deterrents to Soviet employment of such weapons under a nuclear umbrella.[35] But CBW are a poor substitute for nuclear weapons as instruments of deterrence due to several factors: 1) their effects are less predictable; 2) their effects are more susceptible to defensive countermeasures; 3) chemicals are far less efficient than fissile material in causing death and destruction; and 4) in contrast to nuclear and chemical weapons, the ability to inflict mass death and destruction through the deliberate use of biological weapons has never been openly demonstrated. As Saddam Hussein learned, possessing (1990–1991) or just being expected to possess (2003) chemical and biological weapons did not deter U.S.-led international coalitions from invading his country or from overthrowing his regime in the latter conflict.

Further limiting the contemporary deterrent utility of chemical and biological weapons are the treaties that comprehensively ban their possession and use, and which now have nearly universal acceptance. For this reason, pursuit of such weapons by states formally adhering to these treaties must be covert lest they be exposed as violating their treaty obligations. The norm codified in the CWC, the BWC, and the Geneva Protocol also inhibits those outside the treaty who are known or suspected of pursuing chemical weapons from flaunting that capability. Hidden weapons are not effective deterrents, though states could and may intend

to unveil these capabilities in a crisis or during a conflict to achieve pre-war or intra-war deterrence.

According to many accounts, only Syria relied on chemical weapons for deterrence after the end of the Cold War, using its chemical arsenal to deter Israel. Syria was not a CWC state party, and its possession of chemical weapons was undisputed, if not fully acknowledged by the government. After Syria agreed to join the CWC in September 2013, its leadership cited three reasons for abandoning its chemical arsenal. First, it argued that the chemical weapons were usable only in retaliation for a nuclear attack. Second, the effectiveness of Israel's chemical defenses made chemical weapons primarily a psychological weapon. Finally, the weapons had little utility in internal wars. Indeed, Bashar Assad reportedly claimed that by the late 1990s Syria's main use for CW was as a bargaining chip to negotiate a Middle East WMD Free Zone.[36] Whatever the truth of Assad's ex post facto justifications, they communicate a sense that chemical weapons no longer have the deterrent utility some may have once ascribed to them. Indeed, Assad now claims that his country stopped producing chemical agents in 1997 for exactly that reason.[37] Syria's relatively recent covert effort to build a nuclear reactor, which was terminated or at least interrupted by an Israeli aerial strike in 2007, may have reflected its appreciation of the limits of its chemical weapons as a deterrent.

Few states today seem to value CBW for their warfighting utility. With Syria's decision to ratify the CWC in September 2013, North Korea, not a party to the CWC, is the only country widely acknowledged to have a substantial chemical weapons stockpile not declared for destruction under the CWC. Chemical weapons do not appear central to Pyongyang's deterrent posture. Its deterrent capacity has long been underpinned by its ability to devastate Seoul with long-range artillery early in a conflict, whether firing conventional or chemical rounds, and more recently by its overt nuclear weapons program. While not a great deal is known about North Korea's plans for using chemical weapons, it is reasonable to expect that its approach in this area, as in other military areas, derives from Soviet doctrine, in which chemical weapons were integrated into the conduct of operations. North Korea and Syria are both suspected of maintaining biological weapons programs, but less is known about those programs or how these states would

use such weapons.[38] As covert programs, though, their bioweapons capabilities are also more likely geared toward employment than deterrence.

A few other countries are believed to maintain mobilization-based CBW programs. They may value currently available or potential future forms of CBW as secretly developed weapons for employment against unsuspecting or otherwise unprepared adversaries in conflicts of such seriousness that the advantages of employment are perceived to outweigh the political costs and military risks of resorting to proscribed weapons. Alternatively or additionally, such countries may intend their CBW for covert employment in small-scale operations where such use would be hard to confirm or attribute. Capabilities covertly developed and/or delivered have greater prospect of surprising adversaries and securing meaningful military advantages. Iraq demonstrated during its war with Iran that the large-scale employment of chemical weapons against poorly prepared forces could be effective by blunting Iran's human wave assaults.

Notwithstanding CBW's potential uses in some circumstances, the small number of countries known to be or suspected of retaining CBW programs suggests that there is little perceived advantage to acknowledged possession of such weapons and that most countries do not believe CBW provide military capabilities essential for their security in today's environment.

States find no utility in radiological weapons, and terrorists appear to find them of limited attraction. Although considered a weapon of mass destruction, fears in the late 1940s that countries would adopt radiological weapons as a supplement to or replacement for nuclear weapons proved unfounded. Although some countries have explored radiological weapons, no country is known to have introduced them into its arsenal. The only known or suspected state uses of radiological materials have involved assassinations rather than uses in armed conflict. There has been more interest on the part of terrorists, but the only documented incident of a radiological terrorist event was the placement of a radiological source in a Moscow park by Chechens.[39]

Detonation of an explosive radiological dispersion device (RDD) is unlikely to inflict many casualties except for people directly affected by the high explosive, because few are likely to remain near the detonation site long enough to

receive sufficient radiation to cause serious injury. However, depending on the type of radioactive material used, such an attack could lead to long-term radioactive contamination that might have significant economic or societal impact. Passive RDDs are simpler weapons that entail the covert placement of an appropriate radiological source in sufficient proximity to the intended target set, though their effects are far more localized than those of an explosive RDD. The nonexplosive, aerosolized dissemination of respirable radioactive particles is the type of RDD likely to produce the most casualties.[40] It is also the most challenging to engineer as it requires more specialized skills and capabilities to fashion the radioactive particles of the right size, though the approach is essentially the same as for the production of aerosolized solid biological or chemical agents. As for all RDDs, a major challenge for the maker is avoiding lethal exposure in the production process, a factor that may contribute to the general lack of terrorist pursuit of such weapons.

Terrorist interest in WMD has increased, but the limited resources and unsophisticated capabilities available to terrorists have constrained WMD terrorism. There is widespread concern about terrorist pursuit and employment of WMD. As most states have marginalized CBW over the past two decades, terrorist groups have begun to give greater attention to such weapons. Some, most notably al Qaeda, have explicitly expressed their interest in WMD and have been discovered pursuing them.[41]

In the late 1980s and early 1990s, Aum Shinrikyo organized both chemical and biological weapons programs, unsuccessfully employed biological agents, and employed chemical agents with some effect in 1994 and 1995.[42] Militia groups in the United States began exploring biological agents in the 1990s and made several ineffective attempts to employ them.[43] Al Qaeda organized chemical and biological weapons programs in the late 1990s that were primarily intended to produce relatively crude capabilities more suitable for inducing terror than causing mass casualties. More seriously, al Qaeda also made substantial investments in infrastructure to support development of more sophisticated biological weapons focused on anthrax. This latter effort was dismantled in the wake of the U.S. invasion of Afghanistan, and there is no indication that it has been revived.[44] Some al Qaeda affiliates apparently retain an interest in chemical and biological weapons.

The development and employment of CBRN weapons, however, is not a trivial matter. Resources and expertise are required, as well as the time and space to master new technologies. No state is known to have provided a terrorist with a WMD capability or with the expertise needed to create a CBRN weapon. The production of the fissile material required for a nuclear weapon still calls for the resources of a state. It is believed, however, that a sophisticated nonstate actor that somehow acquired fissile material would be capable of improvising a yield-producing nuclear device. Fortunately, this has not yet been demonstrated. While the technical difficulties associated with producing some CBW or radiological weapons are considered surmountable by talented nonstate groups, there are few instances of terrorist groups actually doing it. Aum Shinrikyo's 1995 development and use of the nerve agent sarin is the most sophisticated case of WMD terrorism, but that effort fell well short of producing the military-grade agent the cult sought. Relatively unsophisticated employment of chemical weapons, such as the employment of chlorine by al Qaeda affiliated terrorists in Iraq, has provided no advantages over more traditional munitions.

There are numerous multilateral initiatives intended to reduce the prospects for WMD terrorism. Indeed, it could be argued that there is more real international cooperation in addressing WMD terrorism than in tackling state proliferation, given disagreements among the major powers on dealing with the Iranian and North Korean nuclear programs. International agreements intended to prevent WMD terrorism include UN Security Council Resolution 1540, which obligates all states to act to preclude nonstate actors from acquiring or using WMD of any type. WMD-related terrorism treaties include the Nuclear Terrorism Convention, which requires states to protect radiological materials and facilitate the investigation and prosecution of crimes, including acts of terrorism, involving radiological materials or nuclear devices, and the Convention on the Physical Protection of Nuclear Material.[45] Supporting these formal agreements are informal arrangements such as the Global Initiative to Combat Nuclear Terrorism. Similarly, the Nuclear Security Summits initiated by President Obama were partially intended to promote efforts to keep fissile material out of the hands of terrorists. Counter-WMD terrorism activities are also sponsored by multinational organizations including Interpol, the Organisation

for the Prohibition of Chemical Weapons (OPCW), the World Health Organization (WHO), and the International Atomic Energy Agency (IAEA).

We have a poor understanding of the motivations for acquisition and use of WMD. Intent may best address arguably the most important unanswered question about WMD today, namely why they are so rarely used. That is particularly puzzling for chemical, biological, and radiological weapons given that the requisite capabilities are generally considered to be accessible to state and nonstate actors alike, albeit at differing levels of technological sophistication. While the technological accessibility of these weapons is often grossly overstated, the reality is that even those who possess CBRN weapons rarely if ever use them. State and nonstate actors may have assessed the WMD capability available to them as ill-suited to their needs, preferring other capabilities.

A combination of factors could reasonably explain why possessors have been reluctant to employ WMD in war. In some cases, we believe that CBRN weapons, and especially nuclear weapons, exist principally for deterrence. Official U.S. chemical and biological weapons policy during most of the Cold War thus reserved them for retaliatory strikes if an adversary employed them first. Similarly, nuclear weapons have rarely been considered warfighting tools; rather, they have been valued primarily for deterrence. However, even when the weapons are thought to have warfighting utility, most countries have been reluctant to employ them. Possible reasons for nonuse include the actors' fear of unacceptable reprisals, concern that international responses might complicate the geopolitical environment in ways unfavorable to possessors, assessments that the weapons might not accomplish the desired military objectives due to the effectiveness of defensive countermeasures or other factors, lack of appreciation of their military potential by political or military leaders, and even moral considerations.

While the above comments are aimed primarily at state use of WMD, similar factors appear to be at work with nonstate actors. Terrorist groups have less ability to acquire CBRN weapons than states, but the evidence also suggests that most terrorists have had no interest in acquiring WMD. Terrorist groups may have rejected CBRN because they believe such weapons have no utility. Either they see no need for weapons that cause such effects (they may be able to achieve

their desired outcomes with conventional weapons more readily at hand) or they and the people who support their cause may find WMD morally unacceptable. Unfortunately, we know that not all terrorist groups have reached that conclusion, including both the Japanese cult Aum Shinrikyo, which sought to acquire and use both chemical and biological weapons to cause mass casualties, and al Qaeda, which organized prior to 9/11 a biological weapons program intended to kill large numbers of people. Because such groups may be less inhibited by moral considerations or deterrence by retaliation, many Washington policymakers worry more about terrorist CBRN acquisition than state WMD programs.

WMD-Relevant Technological Trends

Looking now toward 2030, we consulted experts on scientific and technology trends bearing on CBRN weapons, as well as on the possibility that entirely new forms of WMD might emerge—that is, weapons beyond CBRN. We reached a number of conclusions regarding both areas.

By 2030, technological as well as proliferation developments are likely to reduce obstacles to the covert development of nuclear weapons as well as to the development of more sophisticated nuclear weapons. More sophisticated nuclear weapon designs are proliferating, and weaponization technologies that were once cutting edge are now integral to widely available commercial products. These developments should enable those with access to fissile material, primarily new and aspiring nuclear weapons states but perhaps also sophisticated nonstate actors, to produce larger-yield weapons in packages that are smaller, more transportable, and easier to conceal. However, the differences between the resources and capabilities available to a nonstate actor and even a relatively small state are likely to remain substantial.

Acquisition of fissile material will continue to be the principal barrier to nuclear weapons development. International efforts to secure vulnerable nuclear materials have shored up this barrier, particularly for nonstate actors. Efforts to end new production of fissile material have been less successful. Technological advances, especially with regard to lasers, may afford state actors faster, cheaper, and less observable means to enrich uranium within the timeframe of this study. Laser isotopic separation (LIS) is a long understood approach for enriching

uranium to a desired level in a single operation, but it has hitherto been more technologically challenging and costly than today's widely utilized gas centrifuge technology even with the latter's large facility footprint and long run times. Should one or more new LIS processes that leverage recent advances in laser and other technologies prove both effective and competitive, their subsequent penetration of the nuclear power market could enable state and commercial customers to enrich uranium to weapons-grade level with less time, cost, and signature.[46] If that occurs, a world with a greater degree of nuclear weapons latency could emerge, with less opportunity to detect and stem nuclear weapons development programs before they mature. Other technological and commercial developments could also conceivably open new paths to the production or extraction and utilization of the few fissile materials other than U_{235} and Pu_{239}. For example, thorium-fueled nuclear reactors could be used to generate the fissile material U_{233}.[47]

By 2030, nuclear weapons may not become more capable in terms of their ability to defeat defensive countermeasures in that there are no current or emerging defenses against their prompt effects. However, the appearance of more discriminate nuclear weapons in some state programs is possible. Russia is reportedly investing in "clean" as well as precision low-yield nuclear weapons to support its increased reliance on nuclear weapons to deter and defeat perceived security threats along its periphery, particularly from superior NATO conventional forces.[48] New nuclear weapons that use less fissile material than traditional nuclear weapons to produce comparable effects would produce less of the fission products that are the principal source of enduring, secondary (fallout) radiation. Such "cleaner" nuclear weapons may be perceived as more employable, particularly on or near one's own territory, because they have less enduring radiation effects and therefore inflict fewer casualties.

The logical extension of the pursuit of clean fission-initiated nuclear weapons is the development of a pure fusion weapon, in which the atom's power is released without the use of fissile material and thus without the generation of fission products.[49] The United States and Russia are among a number of countries engaged in longstanding efforts to achieve pure fusion for energy purposes,

which could provide an inexhaustible supply of safe, clean power. The National Ignition Facility (NIF) at Lawrence Livermore National Laboratory (LLNL) may one day be the first to achieve pure fusion. In February 2014, LLNL reported that it got more energy out of the fusion fuel than was put into it, an important but still early step toward the production of useful levels of fusion energy.[50] However, the NIF's complex, large-scale approach to producing energy from fusion is not directly translatable into a weapon. Moreover, current U.S. policy prohibits the development of new types of nuclear weapons, at least those with new or enhanced military effects, although substantial improvements are allowed under the rubric of life extension. Other states are not so constrained and may find different ways to develop pure fusion nuclear weapons. Opinion was split among the U.S. technical experts we queried as to whether a pure fusion weapon was feasible by 2030. But whether such nuclear weapons are in exotic or more traditional forms, significant obstacles to development and production are expected to diminish.

By 2030, scientific and technical advances are likely to make available chemical and biological weapons with more useful characteristics than current versions. CBW-relevant technologies are already diffuse and dual use, especially compared to those for nuclear weapons. Driven by commercial interests, the life sciences and related technologies are advancing rapidly on a global scale. There is also a growing convergence of chemistry and biology as commercial entities increasingly use the replicating processes of one to synthesize or express elements or organisms of the other. A common refrain from experts we consulted is that the pace of change is so great in the life sciences that they could not confidently predict where the technology would be in 5 years, much less 20. Experts consistently opined to us that technological developments pertinent to CBW could be expected to favor the offense over the defense in our timeframe of interest. Our overall conclusion is that it is impossible to predict the specific biological and chemical weapons capabilities that may be available by 2030, but clearly what will be possible will be much greater than today, including in terms of discrimination and the ability to defeat existing defensive countermeasures.

To elaborate with regard to biological weapons, the means to acquire and weaponize naturally occurring pathogens are increasingly available and in more readily useable forms for state and nonstate actors alike. For example, the increasingly routine practice of geo-tagging images made available over the Internet can vector those interested in harvesting pathogens from nature to the specific source of virulent disease outbreaks when such images are posted as part of reporting on the outbreaks. Successive, selective culturing can be utilized to identify strains that are especially virulent or more resistant to existing medical countermeasures. Presterilized, multiliter bioreactors can be obtained over the Internet and used to multiply the desired strains. Commercially available agricultural sprayers can enable high efficiency dissemination of liquid pathogen solutions without special adaptations.

The foregoing capabilities do not involve genetic manipulation or bioengineering; they utilize longstanding biological knowledge and processes. More sophisticated understanding of biological systems (genomic and proteomic information) and processes (genetic modification, bioengineering) for manipulating those systems is emerging rapidly. While the amount of new data about biological systems is expanding more rapidly than understanding of their significance and utility, the expansion of such understanding is inevitable. That understanding can be expected to further reduce the barriers to the development of existing types of biological weapons and possibly also lead to the development and application of new and more capable weapons. Possibilities include making naturally occurring pathogens more stable in the environment and harder to detect; enabling de novo production of pathogens, especially viruses, that are not available or at least not readily so in nature (such as smallpox); and creating novel pathogens with hitherto unseen properties, perhaps even deliberately designed to have such properties through the exploitation of molecular modeling and engineering.[51]

Such advanced bioweapons capabilities are most likely to emerge out of state programs, but the underlying information as well as the tools for genetic manipulation will be widely available. It is therefore possible that new and highly pathogenic agents will emerge from the work of nonstate actors and even of individuals, who may or may not have malign intent. Indeed, one of the more serious concerns about the future of biology is that do-it-yourself biologists

will inadvertently create and release a dangerous pathogen into the environment with grave consequences.[52]

With regard to chemical weapons, chemical manufacturing is globalizing, and with it the skills and capacity that can be used for CW purposes. Commercial firms have exploited more powerful computing and other new technologies to create and screen large numbers of new chemical compounds. Some of those compounds may have utility for CW purposes. Microreactors could reduce barriers for state and nonstate actor production of ultrapure chemical agents if they are more widely adopted commercially. Microreactors currently constitute a niche in the chemical manufacturing sector but have the potential for broader adoption. More effective chemical agent delivery methods will emerge, leveraging encapsulation and nanotechnology. These delivery methods can also be utilized for biological agents.[53]

More sensitive information about existing nontraditional agents is reaching open sources despite efforts to prevent proliferation, making it likely that such agents will be more widely possessed by 2030. Another development that may be encountered at any time between now and our 2030 horizon is the combination of different CBW agents into single weapons, which would compound the difficulties of identifying the associated agents and countering their effects. Such combinations can group different types of chemical agents, chemical and biological agents, and different types of biological agents. A clear implication of rapid developments in the life sciences and related disciplines bearing on biological and chemical weapons is that we are likely to encounter unknown agents and must prepare accordingly.[54]

Ultimately, we believe that CBW agents will be 1) more accessible to both state and nonstate actors due to lower barriers to the acquisition of current and currently emerging CBW technologies; 2) more capable, particularly in terms of their ability to defeat current or currently-emerging defensive countermeasures; 3) more discriminate—that is, more precisely targeted and/or more reliably low- or nonlethal; and 4) harder to attribute (utilizing hitherto unknown agents and/or delivery mechanisms) than the traditional forms known today.

No major new technological developments regarding radiological weapons are foreseen. Barriers to access are already low given the extensive medical and industrial

utilization of radiological materials, the ready availability of high explosives, and the straightforward ways in which radioactive material can be coupled with high explosives to produce an explosive RDD. This is not expected to change significantly by 2030.

It is unlikely that entirely new forms of WMD will emerge by 2030, at least as WMD are defined by the United Nations. Technological developments have raised questions as to whether there will emerge new types of weapons with impacts comparable to CBRN.[55] At least one international leader has foreseen such developments. In February 2012, then Russian Prime Minister Vladimir Putin wrote:

> *In the more distant future, weapons systems based on new principles (beam, geophysical, wave, genetic, psychophysical and other technology) will be developed. All this will, in addition to nuclear weapons, provide entirely new instruments for achieving political and strategic goals. Such hi-tech weapons systems will be comparable in effect to nuclear weapons but will be more "acceptable" in terms of political and military ideology. In this sense, the strategic balance of nuclear forces will play a gradually diminishing role in deterring aggression and chaos.*[56]

We are more skeptical, at least out to the 2030 timeframe. Some of Putin's "new principles" clearly relate to existing categories of weapons incorporated into the longstanding WMD definition and definitively banned by existing arms control agreements. The "genetic" weapons Putin referred to would be a type of biological weapon, and thus not a new type of WMD at all. It is less apparent what he means by psychophysical weapons, but he may be referring to biological or chemical agents that could alter a victim's state of mind or physical functions in a nonlethal way. In either case, all of these weapons are restricted by the BWC and/or the CWC.

We investigated a number of candidates for new forms of WMD including weapons utilizing high-powered microwaves (HPM) or other forms of directed energy (DE), hypersonic kinetic energy, ultra-high explosives and incendiary materials, antimatter, and geophysical manipulation. Weapons utilizing HPM, other

DE, or hypersonic energy hold great military potential, but they are either more disruptive than destructive or their destructive effects are more discriminate or localized than those currently associated with nuclear, biological, or chemical weapons. Such weapons, along with cyber weapons, could certainly amplify the effects of WMD attacks, for example, by disrupting communications and other electronic systems that are important to coordinating responses to WMD attacks. Ultra-high explosives or incendiary materials are more likely to approach a layman's definition of a weapon of mass destruction; antimatter weapons, with the potential to inflict destruction on a greater scale than nuclear weapons, most certainly would meet such a definition. However, the experts we consulted considered the emergence of such weapons unlikely by 2030.

The growing cyber threat could eventually force a reconsideration of the meaning of WMD. We also examined cyber weapons, but initially not as a potential new form of WMD. Cyber weapons were assessed only as to their ability to facilitate CBRN events, such as manipulation of supervisory control and data acquisition (SCADA) systems to cause a Bhopal-like release of a lethal chemical agent from a chemical manufacturing facility. Cyber weapons were found to indeed have the potential to enable CBRN incidents. If targeted facilities or their operators are dependent on information technology, it is possible to use cyber weapons to manipulate or otherwise disrupt their functions in ways that could result in the harmful release of WMD material or at least facilitate unauthorized access to the material, such as through the disabling or spoofing of security systems. Facilities and their operators are already dependent on information technology to varying extents and will become more so in the future, especially on networked systems. Cyber weapons can enable CBRN events not only through direct manipulation of SCADA systems or by interrupting connections to external sources of power, but also by causing human operators to misread situations and unintentionally take adverse actions. Indeed, since almost everything we do is dependent on information systems, cyber weapons can affect human operations by an exceedingly broad number of ways and means.

As we learned more about the scope of what cyber weapons might be capable of in the future, we concluded that they need to at least be part of the conversation

about what will constitute WMD. This arises not because the first-order effects of cyber weapons are necessarily more lethal or physically destructive than other candidates we considered but ultimately dismissed as new forms of WMD. They likely would not be, though the second and third order could be quite substantial in these regards. Rather, it is because the sheer scale of societal disruption that cyber weapons may be able to inflict by 2030 could have such strategic impact as to provoke strategic-level responses.

Societies in the 21st century will become increasingly vulnerable to forms of *disruption*, and such disruption may be as strategically important as *destruction*. They will become more dependent on networked information systems as commercial and governmental entities alike are driven to achieve greater efficiencies. SCADA devices allowing wireless connection, monitoring, and control of virtually every aspect of modern life, including life-sustaining medical implants in the human body, will make modern societies, and the upper socioeconomic strata of developing nations, more vulnerable to information system attack than ever before. As with the life sciences, the rapid pace of change in information technology is expected to accord an advantage to the offense over the defense for the foreseeable future.

If the impacts of large-scale cyber attacks could be so great and our ability to defend against such attacks is so uncertain, it is reasonable to expect that we will become more dependent on the threat of an "overwhelming and unacceptable" response to deter such strikes, as Presidents have long been to deter the threat of traditional WMD attack. As the growing attention being paid to the challenge of "cross-domain deterrence" suggests, such deterrent threats should not be assumed to be limited to retaliation-in-kind. Of course, the effectiveness of such deterrence threats will depend to a large extent on our ability to attribute the source of cyber attacks, a major problem that will demand even greater focus going forward.

WMD-Relevant Geopolitical Trends

An examination of WMD-relevant technological trends is necessary but insufficient to envisioning the future of WMD. It helps us understand what the future *nature* of WMD may be, but not its future *role*. One must plumb intent to hope to understand that role. Intent to acquire and use WMD, as with other

types of weapons, is driven by political-military considerations that are shaped by geopolitical circumstances and national or group interests as perceived through the prisms of historical experiences and, for some, religious and ideological beliefs. Understanding intent to acquire and use WMD in 2030 necessitates judgments about the geopolitical environment that will exist. To that end, we reviewed a number of studies of future trends by the U.S. and foreign governments and consulted experts at several think tanks. We offer the observations below about WMD-relevant aspects of the future geopolitical environment.[57]

The United States will remain the world's most powerful country through 2030, but will be less dominant in an increasingly multipolar international system. The 2008 financial crisis led to a cottage industry of analysts who proclaimed that the United States would soon be supplanted by China as the world's most powerful country. Other pundits posited that an alternative bloc of countries—Brazil, Russia, India, and China (the so-called BRICs)—was likely to supersede the Western powers. We do not expect the United States to be supplanted as the top power by 2030, but we do anticipate a significant decline in its relative power as well as that of its Western allies.

Several factors will account for the *relative* decline of the United States. The economic emergence of developing countries, most importantly China and India but also such states as Brazil, Indonesia, Turkey, Vietnam, and Nigeria, will erode the share of global wealth and power currently held by the United States and the Western powers generally. The U.S. National Intelligence Council projects, "Asia will have surpassed North America and Europe combined in terms of global power, based upon GDP, population size, military spending, and technological investment. China alone will probably have the largest economy, surpassing that of the United States a few years before 2030."[58]

Indeed, the world's population and wealth are expected to increase overall, albeit with regional exceptions. By 2030 the global population will grow by approximately one billion people, and the number classified as middle class is expected to exceed those who are poor for the first time.[59] Growth will be most pronounced in the developing world, especially in South Asia, the Middle East, and Africa, and will more than offset the stagnation or decline of

the populations of most developed Western countries and Russia (the United States will be the exception). In what the U.S. National Intelligence Council refers to as a "tectonic shift," the populations of the Western countries and increasingly most developing countries will significantly age.[60] The financial burden resulting from aging populations may make it harder for many countries to sustain existing funding levels for national security.

While the United States should remain the preeminent military and economic power out to 2030, it will not be hegemonic. It and its Western allies and partners will probably find it increasingly challenging to exercise global influence. As the European Union's Institute for Security Studies foresees, "The international agenda will very likely cease to be essentially Western-driven and will shift to accommodate and address the priorities of a much broader and more heterogeneous range of states, and the concerns of citizens in newly-developed nations."[61]

The United States will also find it more costly and risky to project power in the regions of the rising big powers, particularly in Asia. Rising big powers such as China and India can be expected to assert themselves. More actors will possess advanced conventional weaponry, such as long-range precision strike munitions and other access denial capabilities. As one British defense study observes, "It cannot be assumed that by 2029 the West will retain sufficient military advantage over rising powers in all circumstances. . . ."[62] Thus greater uncertainties will attend the outcomes of U.S. conflicts with rising big powers, especially in their own regions. This could have important implications for the rich network of security arrangements the United States developed during the Cold War. Washington's allies and partners can be expected to have more questions about U.S. willingness and ability to engage in conflicts with emerging powers in their defense, and may feel the need for alternative security measures.

Nonstate groups, potentially including terrorists, will grow in capabilities and importance. As the U.S. National Intelligence Council argues, "A growing number of diverse and dissimilar state, subnational, and nonstate actors will play important governance roles in an increasingly multipolar world."[63] To the extent the traditional nation-state cannot satisfy the needs of its populace, a governance gap could emerge that would supplement or even supplant the state in

some circumstances. The National Intelligence Council worries that this diffusion of power could include acquisition of military technologies including weapons of mass destruction, precision strike conventional weapons, and cyber capabilities once limited to states. Others agree but couch the problem in other terms. The European Union also sees a diffusion of power it fears might result in greater political fragmentation.[64]

Failed states will continue to pose difficulties for the international community. Since the end of the Cold War, some states have failed to cope with challenges to their integrity and have either collapsed or lost significant control over portions of their territories and populations. Failed states and the ungoverned spaces they create can provide havens for nonstate actors to pursue illicit activities inimical to international security. A failed Somalia furnished a base for piracy that has required a multinational naval task force and other measures to contain. A breakdown of government authority in Mali in 2012 enabled Islamists to seize control of that country's northern half, prompting French intervention to roll back the Islamists' gains. Syria's civil war raised concerns that its large chemical weapons stockpile could fall into the hands of terrorist groups. Failed states can be expected to be an enduring feature of the future environment. At least some of the states currently at risk for failure are nuclear-armed, including North Korea and Pakistan.

The result will be a continued threat of violence from nonstate actors. A British Ministry of Defence study foresees ongoing threats from terrorism.[65] The U.S. National Intelligence Council also anticipates continuing threats from violent extremists, but it is more hopeful that Islamic terrorism has peaked and will decrease in the future, akin to the cyclical nature of earlier waves of international terrorism such as the anarchist movement of the late 19th century, the postwar anticolonialist terrorist movements, and the New Left in the 1970s.[66]

Sources of international conflict will remain and could intensify, and the risks for armed conflict, both inter- and intrastate, will increase. Most government studies of future conflict trends we consulted are pessimistic about the future, seeing a number of developments increasing the risks for interstate and intrastate armed conflict. These developments include 1) growing competition over key resources,

2) greater ideological diversity and contention, and 3) instability historically associated with the transition to a more multipolar international system.

A straight-line projection of recent trends would not support such pessimism. The post–Cold War world has experienced a decline in the number and intensity of intra- and interstate armed conflicts, continuing a long-term trend that began after World War II. We now live in one of the least violent eras in world history, whether the measure is the number or the intensity of armed conflicts fought by major powers, interstate conflicts involving smaller states, or intrastate conflict.[67] Explanations vary for what John Lewis Gaddis called "The Long Peace" during the Cold War's waning days, but fears of nuclear escalation likely played a major role in muting the great powers' willingness to engage in even minor armed conflicts with other nuclear-armed states.[68] The Human Security Report Project argues, "It is difficult to determine the causes of peace between developed states with any degree of precision—not because there are too few plausible explanations, but because there are too many."[69] Intrastate wars, which one analyst has called "societal wars," now constitute the predominant form of armed conflict.[70] Past performance, however, is not a guarantee of future performance.

Competition over key resources (food, clean water, and energy) is likely to increase over the next two decades. This will be driven by growth in the world's overall population and wealth and, to an uncertain extent, climate change. New technologies hold the promise of enabling global supplies of these resources to keep up with global demand,[71] but there will be geographic disconnects between the sources of supply and demand. Key resource scarcities will be most acute for countries with persistently high population growth and the most youthful populaces, especially in Sub-Saharan Africa and South and East Asia.[72] India and China are also likely to be major importers of key resources. The United States, in contrast, will likely remain a major food exporter and, in a dramatic turnaround, may become a net energy exporter by 2020.[73] Efficient and reliable distribution systems will be required to match supply and demand across the globe, but as always there will be plenty of scope for deliberate and inadvertent obstruction of such systems. Increasingly powerful states with large import requirements may

seek to secure access to external resources in ways that bring them into conflict with other states. One U.S. Government study concludes:

> *Competition over resources might lead governments to become increasingly involved in managing them, ramping up tensions with other countries vying for the same resources. Effective global governance would be necessary to avoid such tensions escalating and to ensure against the risks of mercantilism and protectionism infecting the global economy. Such risks are greater in a multipolar world marked by wide divergences in domestic forms of capitalism and differences regarding how to manage the international system.*[74]

While competition for resources may generate greater conflict among states, it does not follow that the inevitable result will be more *armed* conflict. As others have noted, predictions during recent decades that wars would be fought over contested resources such as water have rarely proven true. Indeed, past experience suggests that most such conflicts will be resolved well before escalating to the point of war.[75] Yet greater competition over such basic resources would increase the *risk* of armed conflict.

Greater ideological diversity and contention are also foreseen. A U.S. study expects that a "world of surging middle classes, varying economic potentials, and more diffuse power will . . . exhibit an increasingly diverse ideological landscape." It sees religion, particularly Islam, challenging "the West's conception of secular modernity" and an intensification of nationalism, "particularly in regions—such as East Asia—where there are unresolved territorial disputes and countries' fortunes may be rapidly changing."[76] A British Ministry of Defence study anticipates an increase in ideological conflict driven by "liberal democratic values, autocracy, religious, nationalist or other influences."[77] A European Union study is more optimistic that future developments, particularly the greater connectedness of the world of 2030, will lead to a convergence rather than a divergence of outlooks.[78]

Fundamental changes in the structure of the international system are expected to further increase the risk of armed conflict. Greater multipolarity and the

transition thereto have historically been associated with greater instability and conflict among states in the international system. The aforementioned increased competition for resources and possibly over ideology will provide more opportunities for conflict both among and within states. More state and nonstate actors will have further access to advanced weaponry, which could increase both instability and the intensity of those conflicts that do break out.

While the great powers will endeavor to avoid direct conflict with one another given the associated high costs and risks (for example, all or most of the likely major powers in 2030 are currently nuclear-armed), they can be expected to pursue their conflicts indirectly, such as through allies and proxies or by means that are difficult to attribute.[79] The risk of direct conflict between great powers will not be negligible, though, given the ever-present possibility of miscalculation.

The "battle of narratives" will be an increasingly important part of armed conflict. Globalization is expected to continue over the next two decades, making states, groups, and individuals even more connected, both through economics and communications. Greater connectedness will increase transparency and awareness of developments at home, regionally, and globally. It will provide greater scope for informing and mobilizing diverse sets of individuals and enhance the influence of nonstate actors in the international system. As a European Union study observes, "The citizens of 2030 will be very much more aware that they are part of a single human community in a highly interconnected world."[80]

The importance of establishing the legitimacy of one's resort to force can be expected to grow in an increasingly connected world. A U.S. military assessment explains that, "Modern wars are fought in more than simply the physical elements of the battlefield. Among the most important of these are the media in which the 'battle of narratives' will occur."[81] As a British defense study observes, "Conflict *will* remain focused on influencing adversaries, neutrals and those at home, whose perceptions *will* be vital. . . . Influence activity, the battle of ideas, and perceptions of moral legitimacy *will* be important for success."[82] State and nonstate actors alike will exploit a wide variety of media and the 24-hour news cycle to that end.

The increasing importance of the "battle of narratives" to armed conflict could increase the appeal of weapons that are more discriminate or whose employment

is harder to attribute, including future forms of WMD with such characteristics. It could also constrain use of such weapons if the user loses control of the narrative. In essence, that is what happened to Syria during 2013, as discussed further below.

WMD in 2030

What conclusions can be drawn about the future of WMD in the 2030 timeframe in light of the foregoing technological and geopolitical developments envisioned? The following broad thoughts are offered.

Longstanding efforts to exclude WMD from international competition and conflict could be undermined. The future role of WMD will be determined by many factors including technological and scientific advances, the changing geopolitical environment, the character of the military challenges confronting states, the status of terrorism, and the choices world leaders make.

There are numerous reasons to worry that current and past progress toward marginalizing WMD and minimizing further proliferation will be jeopardized in the coming decades. Some of the concern may result from perceptions. Given past success in marginalizing CBR weapons, the main challenge will be to sustain the commitment to ensuring that those weapons remain marginalized. There is little room to reduce the role or legitimacy of those weapons further, but there is considerable risk that the existing regimes could be undermined. While it is the policy of the United States to further reduce its reliance on nuclear weapons, and the policy of many countries to eliminate all nuclear weapons, current trends suggest that it will be difficult. Indeed, it is possible that more countries will come to view nuclear weapons as essential to their security. Additional CBRN proliferation in even a single country could challenge existing regimes, as would the emergence of perceptions that some countries see new or increased utility in possessing or being seen to possess CBW.

Growing insecurity associated with a shifting and uncertain geopolitical environment, where the rise of new powers will reduce the United States and its Western allies' share of global power, could increase the incentives for a number of states to acquire nuclear and even other WMD capabilities to deter and/or defeat aggression. The U.S. security umbrella has shaped the proliferation landscape for

decades. In some cases, allies have explicitly relied on Washington in preference to developing indigenous capabilities. In other cases, the United States has used dependence on its military power as a nonproliferation tool to push for suspension of WMD programs.[83] Should U.S. allies and partners come to doubt the credibility of U.S. security guarantees, they can be expected to look for alternative means to ensure their security. This may increase the appeal of WMD. Indeed, the greatest proliferation challenges during the coming decades may emerge from countries friendly to the United States, not from the so-called rogue states that have preoccupied our attention in the post–Cold War era.[84]

Reaching for nuclear weapons or other forms of WMD is not the only or necessarily the principal recourse for those who fear for their security against rising or otherwise hostile powers. Other options include establishing or strengthening alliances with like-minded nations, relying on the United Nations or other multilateral forums to prevent or respond to aggression, and attempting to accommodate the interests of the rising or otherwise hostile powers. However, the WMD option is less reliant on the interests and dependability of others.

Technological trends, moreover, are expected to reduce barriers to the development of current and emerging forms of WMD, making such weapons increasingly accessible to more state and nonstate actors. These developments especially affect chemical and biological weapons, but are true to some extent even for nuclear weapons. Thus, while access to fissile material will remain a constraint on nuclear proliferation, the technology and equipment required to design and fabricate a nuclear device are increasingly available. Technological trends are also expected to enable WMD to be developed in ways that lack the traditional signatures monitored by national intelligence agencies and international nonproliferation observers. That would afford the international community less opportunity to detect and react to proliferation efforts before they mature.[85]

Nonproliferation regimes and their supporting monitoring and verification measures, whether national or international, will be hard pressed to adapt to these technological advances. Even if proliferation is detected, existing nonproliferation tools may have limited utility. For example, export controls may be less effective in an era when additive manufacturing (three-dimensional printing)

will enable on-site manufacture of hardware needed to support WMD production. The CWC's law enforcement exemption could also be more widely exploited than its drafters foresaw to the extent that more reliably low- and nonlethal chemical agents emerge in the future. Such technological developments could undermine confidence in the ability of nonproliferation agreements and regimes to dissuade and preclude proliferation. It could also lead some states to assume that WMD has proliferated more widely than has been observed and to act accordingly to safeguard their security, possibly by acquiring their own WMD.

The smaller share of global power the United States and its Western allies will hold by 2030 will also test the commitment of the rising non-Western powers to the current nonproliferation and arms control treaties and regimes, which the Western nations have been the primary force behind establishing, implementing, and enforcing. The Soviet Union demonstrated contempt for the Biological Weapons Convention by intensifying its biological weapons program after joining the convention, and there is concern that Russia perpetuates that contempt if perhaps less expansively.[86] Russia and China have been the principal constraints on stronger international action to compel Iran and North Korea to halt or abandon their suspected or acknowledged nuclear weapons programs. Likewise, some developing nations who are States Parties, especially many in the nonaligned movement, have resisted, or at best have been reluctant to support, efforts to reorient the OPCW toward a greater focus on nonproliferation, giving priority to protecting their domestic chemical industries from international interference.[87] If the United States and its Western allies wield less international influence in the 2030 timeframe, and are less able or willing to commit their forces and treasure to upholding nonproliferation treaties and regimes, it is at least questionable whether new, non-Western rising powers will fill the void—particularly if new technological possibilities and changed geopolitical circumstances make WMD more accessible and useful for deterring and prosecuting conflict.

We should stress that none of the challenges described here necessarily lead to a more proliferated world or to the breakdown of the nonproliferation regimes. They do suggest that proliferation prevention and nurturing nonproliferation norms will be difficult. Strong leadership will be required to sustain the regimes

in this more challenging environment, and it remains doubtful that there is any alternative to a strong American role. It will be particularly difficult if U.S. security guarantees are no longer seen as credible and no plausible successor security architecture emerges.

Nuclear weapons are likely to play a more significant role in the emerging international security environment. The incentives for the retention or acquisition of nuclear weapons are likely to increase in 2030. This will arise most fundamentally from a less certain and secure geopolitical environment. In such a setting, the existing nuclear weapons states will be disinclined to part with or significantly pare their nuclear arsenals, and some nonnuclear weapons states that perceive their security to be at greater risk will be more inclined to acquire nuclear weapons or the means to obtain them in fairly short order. A common element of the various visions that have been articulated for the eventual elimination of nuclear weapons is the importance of resolving the sources of regional conflict, but that will be even harder in the shifting geopolitical environment of 2030.[88] Nuclear weapons will remain valued because they will continue to possess an unparalleled capability for deterring threats to one's most vital interests, given their demonstrated and unmatched capacity for prompt, massive destruction against which there is no effective defense.

Just as Washington's reliance on nuclear weapons waxed during its Cold War standoff with its Soviet peer competitor and then waned as it emerged as the world's sole superpower, the pendulum will likely swing back toward greater reliance as one or more new peer competitors emerge. Russia will have no less reason to value its nuclear forces in 2030 given its unavoidable demographic decline and uncertain economic prospects. China may be challenging U.S. conventional military superiority by 2030, at least regionally, but it will not be conventionally powerful enough to forsake the deterrent value of its own nuclear arsenal. Even the United States did not abandon its nuclear weapons during its "unipolar moment." As is the case today, India's nuclear posture will be most informed by China. Pakistan will rely on its nuclear arsenal to compensate for its endemic conventional inferiority to India. Iran may well have acquired a nuclear arsenal by 2030, potentially spurring regional rivals to acquire or pursue their own nuclear weapons. If North Korea endures until 2030, it will likely continue to view its nuclear arsenal as an essential deterrent to external

aggression. The regime there tellingly observed that Muammar Qadhafi's abandonment of his nuclear weapons program left him vulnerable to his Western-assisted violent overthrow.[89] Other states may reach similar conclusions about Russia's invasion of Crimea in March 2014. In 1994, Ukraine concluded an agreement with Russia, the United States, and the United Kingdom whereby Ukraine would give up its nuclear weapons and the signatory states would respect Ukraine's sovereignty. Russia revealed the hollowness of that promise in Crimea.

Nuclear weapons may even come to play an important, if implicit, role in the deterrence of large-scale cyber attacks. If the impacts of such attacks could be so great and our ability to defend against them is as uncertain as was discussed earlier, it is reasonable to expect the United States, at least, to become more dependent on the threat of an "overwhelming and unacceptable" response to deter such strikes, as U.S. Presidents have long done to deter the threat of traditional WMD attacks. As the growing attention to the challenge of "cross-domain deterrence" suggests, such deterrent threats should not be assumed to be limited to retaliation-in-kind. Of course, the effectiveness of such deterrence threats will largely depend on our ability to attribute the source of cyber attacks, a major problem that will demand even greater focus going forward.

Nuclear weapons will also be more accessible to those who choose to develop them, as previously discussed. Fissile material production is the principal technological obstacle to nuclear weapons development, as functioning weapons designs are already available in open sources.[90] Two U.S. allies who may be most inclined to pursue nuclear weapons to safeguard their security against a resurgent China either already produce their own nuclear fuel (Japan) or have developed their own plutonium reprocessing technology (South Korea).[91] North Korea and Iran have most recently demonstrated that less advanced nations can master reprocessing and/or enrichment in the face of strong international opposition. The potential emergence by 2030 of commercially viable and prevalent laser isotopic separation techniques for enriching uranium could enable states to produce fissile material more quickly, cheaply, and covertly than current technologies permit. The force of nonproliferation regimes and norms may also erode as proliferation prevention becomes harder and rising powers may be less attached to them. More discriminate nuclear weapons may

emerge that are viewed as more employable and thus more suitable for a broader range of political-military purposes, especially if other countries choose to emulate Russia in this regard.

Current constraints on state acquisition and use of chemical and biological weapons could diminish. Technological and geopolitical developments could make CBW more attractive by the 2030 timeframe and undermine the calculus that has marginalized their role today. Ultimately, it will be their perceived military utility that will determine whether or not CBW recovers its former role. What factors might lead to such a reversal?

First, if the absence of chemical and biological threats leads to reduced focus on CBW defenses, the perceived military effectiveness of these weapons could grow. Given scientific and technological advances, retaining existing defenses may not be sufficient. Rather, it will be necessary that CBW defenses be seen as adaptive and flexible, and thus able to respond to unexpected new threats.

Second, the dissuasive force of nonproliferation regimes and norms may be undermined if novel chemical and biological weapons emerge that are seen to offer distinct operational advantages to military and other state security forces relative to conventional alternatives. Agreements and norms are only means toward the accomplishment of national security goals. They are products of the geopolitical and technological circumstances of their time and should not be considered immutable even if they were originally conceived to be of indefinite duration. The Anti-Ballistic Missile Treaty was considered to be the cornerstone of nuclear arms control, but the United States withdrew from the treaty when technological and geopolitical circumstances changed. In this respect, it is worrying that Russian officials openly advocate developing genetic weapons despite their country's BWC obligations.[92]

Third, even if a nonproliferation regime is not abandoned, exceptions and ambiguities in its text may be exploited or reinterpreted to provide at least a legal veneer for activities that previously would have been considered dubious at best. In 2002, Russia demonstrated that a CWC state party could employ chemical agents intended to incapacitate rather than kill as part of a domestic counterterrorism operation. Moscow escaped censure even though the agents killed at least 117 innocent

civilian hostages.[93] The muted international reaction to this use shows that there is a grey area in norms and legal prohibitions pertaining to CW. In particular, the Russian case suggests that the CWC exception for the use of temporarily incapacitating chemical agents for law enforcement purposes may provide cover for States Parties to develop, produce, stock, train with, and employ agents whose range of lethality may make them suitable for military as well as law enforcement purposes. Future technological developments may give rise to a broader range of agents that could exploit this CWC exception. In contrast, the BWC unambiguously prohibits any use of biological agents as weapons of war, including those based on new science unknown at the time the treaty was negotiated.

Finally, in a more interconnected world where the battle of narratives will play a larger role in determining the outcome of conflicts, the capacity to obfuscate or justify one's use of force will become even more highly valued. Depending on circumstances, this could either inhibit or encourage proliferation of CBW. Indications that the Syrian regime employed small quantities of chemical agents on multiple occasions prior to their large-scale attacks on Ghouta in August 2013 provoked no serious international reaction, given their limited impacts and the difficulty of confirming the employment.[94] The lack of serious international reaction to those small-scale employments may have contributed to the subsequent attacks on Ghouta. The Ghouta attacks, however, were too large to obfuscate in the contemporary media environment. The swift exposure and strong international condemnation of the attacks, facilitated by social media that spread descriptions and images almost in real time, clearly played an important role in the regime's decision to cease CW use and join the CWC.[95]

To the extent it becomes possible to create WMD that are more discriminate and/or harder to attribute, international actors may have fewer qualms about employing them. We expect future scientific and technological developments to enable chemical and biological weapons that are more reliably low- or nonlethal (for example, incapacitating) and, for biological weapons, capable of being targeted against specific individuals or groups. On the nuclear side, there are indications that Russia is already investing in low yield and "clean" nuclear weapons to make their use more credible in line with their increased reliance on

nuclear weapons to deter and defeat the major security threats they perceive. We also anticipate chemical and biological weapons whose employment is harder to attribute. Chemical and especially biological forensics are already very challenging areas. A historical attraction of chemicals and pathogens for assassinations has been their difficultly of attribution. As previously unknown chemical and biological agents are developed and employed, one can expect even fewer leads by which to trace their origins, at least initially.

As Syria's small-scale employment of chemical weapons in early to mid-2013 illustrated, discriminate use of WMD may not be constrained by international pressure or nonproliferation norms. To the extent that future WMD attacks are substantially more discriminate in their effects than are expected from WMD today, such attacks are less likely to reinvigorate the existing norms against WMD employment by reminding the world how horrible these attacks can be. In such a situation, WMD would begin to look more like just another weapon, though perhaps one in need of a new umbrella term.

There will be a somewhat greater scope for WMD terrorism by 2030, but it is likely to remain a low-probability but potentially high-consequence event. Chemical and biological weapons, which heavily utilize dual-use technologies, are most likely to feature in any future WMD terrorism incident. The increased diffusion of scientific and technological knowledge and capabilities through publicly accessible media such as the Internet should afford nonstate actors greater opportunity to directly acquire, assemble, and employ chemical and biological weapons. Ongoing efforts at the national and international levels to more fully account for and secure known radiological sources and develop alternatives to the use of especially dangerous radiological materials should reduce the accessibility of radiological sources, including fissile material, to nonstate actors.[96] The disincentives for states to transfer WMD or enabling technology to a terrorist group intentionally are likely to remain strong, notwithstanding technological and geopolitical developments that may weaken constraints on states' acquisition and even employment of WMD. These weapons will remain internationally proscribed relative to conventional weapons, and terrorists are inherently risky proxies to whom states should remain very wary of entrusting such sensitive capabilities.

The most serious nuclear terrorism risk arises from possible loss of state control of nuclear weapons. As recent events in the United States suggest, even mature programs can show alarming lapses in nuclear security, suggesting that we should not take for granted the continued ability of existing nuclear weapons states to ensure that they retain control over their arsenals. Should additional proliferation occur, as suggested above, there will be additional nuclear-armed states needing to learn and mature procedures for protecting their weapons.

The most alarming prospect for nuclear terrorism, however, is political upheaval in, or even the collapse of, a nuclear-armed state that results in loss of control of one or more nuclear weapons. It is quite plausible that at least one nuclear weapons state could undergo such turmoil by 2030, which at least opens the prospect that terrorists may be able to obtain weapons. For prudential reasons, we should assume that any terrorist acquiring a nuclear weapon will try to employ it, although that outcome might not be inevitable.[97]

It is not evident, though, that nonstate actors overall will be more motivated to perpetrate WMD terrorism than they are today. As previously discussed, the paucity of WMD terrorism to date is probably more attributable to a lack of intent on the part of terrorist groups than to their inability to acquire WMD, especially unsophisticated forms of CBW. An increased risk of CBW terrorism in the 2030 timeframe will likely be concentrated in more technologically enabled small groups or even lone actors who are inherently harder to identify, influence, or interdict than larger, organized groups. This would create a growing possibility for what Martin Shubik called "Armageddon on the cheap."[98]

Overall, we expect WMD terrorism to remain a low-probability, but potentially high-consequence threat. After all, only a single terrorist group needs to have the motivation, organization, technical wherewithal, and operational competence to transform WMD terrorism from a nightmare to a reality. While it is possible that 2030 could arrive with no terrorist acquisition or use of CBRN weapons to inflict mass casualties, the danger is very real.

It is impossible to predict future employment of WMD. Some prognosticators have made bold predictions as to the certainty of certain WMD employment events occurring within specific timeframes. We foresee greater scope for employment by

both states and nonstate actors by 2030, but no one can predict with confidence whether and how often such attacks will occur or their severity.

The prospects for WMD employment are not the result solely of chance. Other factors will include the accessibility of these weapons and the extent of additional proliferation, the strength of nonproliferation norms and the willingness of the international community to enforce them, the kinds of military threats facing countries capable of creating CBRN weapons, how nonstate actors perceive the utility of WMD to the achievement of their diverse causes, and the escalation dynamics in armed conflicts between states with WMD capabilities. The perceived success of any initial or early cases of WMD employment would influence the likelihood and nature of any subsequent employment. If the employment is considered successful, to include a manageable military, economic, and political response, it is likely to encourage future employment. If it is unsuccessful, it should inhibit subsequent attacks, at least until new approaches to avoiding the pitfalls of the unsuccessful attack(s) are devised.

Denying the ability to predict WMD employment is not a very satisfying conclusion, but there appears to be no basis for making a more definitive judgment. U.S. policymakers should view their commitment to policies designed to prevent such employment in that light.

The definition of WMD will remain uncertain and controversial in 2030, and its value as an analytic category will be increasingly open to question. The definition of WMD will remain controversial. In addition to the longstanding issues identified above, some observers want to incorporate new forms of warfare or new technologies, as evident by suggestions that cyber weapons should be considered a form of WMD or that nanotechnology might result in the creation of new types of weapons capable of causing mass destruction.

Such discussions, however, open a different question: will the category of WMD remain useful during the next two decades? The 21st century strategic environment may require conceptual categories that take the changing nature of weapons and the changing vulnerabilities of societies to new and existing types of weapons into account. Technological trends appear to permit the development of new types of existing forms of WMD that are better targeted, less lethal, and

less destructive, which will further complicate our understanding of this category of weapons.

Policy Considerations

Following are some considerations for U.S. policy in light of the foregoing observations and judgments about the future nature and role of WMD.

As regards WMD generally, the United States should anticipate greater challenges to dissuading and preventing WMD proliferation in the future. It should undertake investigations to determine to what extent and by what means—technologically, geopolitically, and normatively—these challenges can be blunted so as to mitigate their adverse impacts on proliferation prevention. In particular, the United States should investigate:

- how the nonproliferation benefits long demonstrated by U.S. extended deterrence commitments can be sustained or replaced in an era of rising new powers and tighter fiscal constraints
- how the dissuasive force of norms against WMD acquisition and use can be sustained or enhanced as new powers arise and possibly more attractive forms of WMD emerge
- how the capabilities of national and international nonproliferation monitors can be adapted to new technological realities to enable timely recognition and response to proliferation.

Assuming that the adverse impacts of these developments on proliferation prevention are not wholly avoidable, the United States should anticipate that deterrence will become more central to ensuring that it and its allies are not coerced or attacked with WMD. Increased reliance on deterrence will necessitate greater emphasis on, and sufficient investment in, key enablers of deterrence including:

◆ unambiguous capacity to impose unacceptable costs on WMD-armed adversaries

◆ ability to defeat limited WMD attacks, particularly through missile defenses

◆ ability to attribute WMD attack

◆ effective strategic communication of our deterrence capabilities and will to employ them.

While it is not known what has most accounted for the paucity of terrorist use of even cruder forms of WMD to date, or at least employment that has resulted in mass destruction, the combination of strong international norms, intense law enforcement and military pressure, and improved defenses have likely all contributed to this outcome. The United States should sustain and, where possible, intensify this multitude of deliberate obstacles to terrorist acquisition and employment of WMD.

As regards nuclear weapons:

◆ The United States should sustain its strong support for the nuclear nonproliferation regime to mitigate forces tending toward greater nuclear weapons proliferation.

◆ At the same time, Washington should preferentially fund the modernization of its nuclear weapons arsenal and supporting infrastructure to ensure a credible and effective nuclear deterrent to 2030 and beyond.

◆ Deterring and responding to nuclear weapons threats and potential employment should figure more prominently and systemically in U.S. military plans and in the education of military and civilian national security leaders so the Nation is better prepared to manage increasing nuclear risks.

As regards chemical and biological weapons:

◆ The United States should anticipate and prepare for the possible reemergence

of chemical and biological warfare due to some combination of geopolitical and technological change.

◆ Washington should anticipate that it will encounter the employment of hitherto unknown chemical and biological agents and develop a mindset, approaches, and capabilities for recognizing and responding to unknown agent attacks.

◆ The Nation should continue to invest in broad-spectrum defensive countermeasures that are better able to recognize, protect against, and treat a wide range of chemical and biological threats.

◆ Even as it anticipates and prepares for possible reemergence of chemical and biological warfare, Washington should concurrently endeavor to adapt and strengthen nonproliferation regimes and norms to dissuade others from searching for and utilizing novel chemical and biological weapons.

◆ The United States should respond strongly to any suspected nonproliferation treaty violations and be prepared to alter its nuclear weapons negative security assurances to react to a heightened biological or chemical weapons threat from nonnuclear weapons states.[99]

◆ An early nonproliferation regime challenge is to decide whether and how to tighten the current CWC law enforcement exemption to inhibit the further pursuit and utilization of low- or nonlethal chemical agents for malign ends.

As regards radiological weapons:

◆ The United States, working with the international community, should continue to promote efforts to reduce reliance on highly radioactive materials in medical and commercial applications, ensure adequate controls over those that are used, and continue to identify and eliminate orphaned material.

As regards the WMD status of cyber weapons:

◆ While the future cyber threat may foster consideration of strategic responses comparable to those made to the WMD threat, it would seem inappropriate

and possibly disadvantageous to the United States to apply the WMD moniker to cyber weapons at this time.

◆ In addition to the qualitatively different character of cyber from CBRN, there is the matter of disarmament diplomacy and international law. WMD have been given special priority for elimination or control. Several treaties also place specific limitations on the use of WMD, and making cyber a form of WMD would automatically make those provisions apply.

◆ Until the United States better understands whether it wants to develop an international regime constraining cyberspace or to maximize its flexibility to utilize a capability in which it is the acknowledged world leader, there are no advantages to treating cyber weapons as WMD.

Notes

[1] This section draws on W. Seth Carus, *Defining "Weapons of Mass Destruction": Revised and Updated*, Occasional Paper 8 (Washington, DC: NDU Press, 2012).

[2] See U.S. Arms Control and Disarmament Agency, *Documents on Disarmament 1977*, Publication 101, June 1979, 838–841.

[3] Carus, *Defining*, 42, 87.

[4] George P. Shultz et al., "A World Free of Nuclear Weapons," *The Wall Street Journal*, January 4, 2007, A15.

[5] The aforementioned efforts to negotiate a treaty prohibiting new forms of weapons of mass destruction (WMD), dating from the late 1960s, focused mainly on radiological weapons, but were ultimately fruitless. One reason those efforts did not succeed may be that radiological weapons were not considered something that state actors were likely to pursue given their perceived lack of military utility. See Jerzy Zaleski, background paper for the discussion "New forms of WMD, transparency in armaments, and a comprehensive programme of disarmament—obsolete or ignored?" organized by the United Nations Institute for Disarmament Research and the Geneva Forum, May 6, 2011, 9, available at <www.unidir.org/files/publications/pdfs/new-types-and-systems-of-wmd-consideration-by-the-cd-374.pdf>.

[6] For a more comprehensive discussion of international arms control and nonproliferation agreements, see Amy F. Woolf, Mary Beth Nitikin, and Paul K. Kerr, *Arms Control and Nonproliferation: A Catalogue of Treaties and Agreements*, RL33865 (Washington, DC: Congressional Research Service, March 7, 2012), available at <www.fas.org/sgp/crs/nuke/RL33865.pdf>.

[7] "Libya Completes Destruction of its Category 1 Chemicals," Organisation for the Prohibition of Chemical Weapons, February 4, 2014, available at <www.opcw.org/news/article/libya-completes-destruction-of-its-category-1-chemical-weapons/>.

[8] See Department of State, "Adherence to and Compliance with Arms Control, Nonproliferation, and Disarmament Agreements and Commitments, July 2013," available at <www.state.gov/documents/organization/145181.pdf>. This is the unclassified version of this annual report; classified versions also exist. As this is written, Syria is beginning to dismantle its chemical weapons arsenal under international supervision, but it is too early to be certain about its ultimate compliance. Moreover, the International Atomic Energy Agency continues to have questions regarding Syria's compliance with its Nuclear Non-Proliferation Treaty (NPT) obligations.

[9] During a press conference on March 21, 1963, President John F. Kennedy stated, "I see the possibility in the 1970s of the President of the United States having to face a world in which 15 or 20 or 25 nations may [have] these weapons. I regard that as the greatest possible danger and hazard." John F. Kennedy Presidential Library and Museum, News conference 52, available at <www.jfklibrary.org/Research/Ready-Reference/Press-Conferences/News-Conference-52.aspx>.

[10] Why states seriously considered or actually initiated nuclear weapons programs but then pulled back was examined by Rebecca K.C. Hersman and Robert J. Peters in their "nuclear roll back" research project in the Center for the Study of Weapons of Mass Destruction at the National Defense University. A description of the project and their findings regarding South Korea and Taiwan are discussed in Hersman and Peters, "Nuclear U-Turns: Learning from South Korean and Taiwanese Rollback," *Nonproliferation Review* 13, no. 3 (November 2006), 539–553.

[11] When referring to chemical, biological, radiological, or nuclear (CBRN) weapons employment, we mean their use against groups and not to the use of CBRN agents or isotopes for individual assassinations, of which there is a long history that is generally treated separately from discussions of WMD. Thus, for example, we do not count the 2006 murder of former Russian spy Alexander Litvenenko by the contamination of his tea with a radioactive isotope.

[12] Richard Danzig et al., *Aum Shinrikyo: Insights into How Terrorists Develop Biological and Chemical Weapons* (Washington, DC: Center for a New American Security, 2011), 5, 32. In the Tokyo subway attack, 13 were killed and approximately 6,000 sought hospital treatment (probably only a few hundred were seriously injured). At the Matsumoto residential complex, 8 were killed, and approximately 200 were injured.

[13] W. Seth Carus, "The Rajneeshees (1984)," in *Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons*, ed. Jonathan B. Tucker, 115–137 (Cambridge, MA: MIT Press, 2000).

[14] Scott Shane, "F.B.I., Laying Out Evidence, Closes Anthrax Case," *The New York Times*, February 19, 2010, available at <www.nytimes.com/2010/02/20/us/20anthrax.html?pagewanted=all&_r=0>.

[15] An assessment of the al Qaeda in Iraq chlorine car bomb attacks can be found in Michael Knights, "Born of Desperation: AQI's Chlorine Car Bombs, 2006–2007," in Mohammed M. Hafez and Maria Rasmussen, "Terrorist Innovations in Weapons of Mass Effect, Phase 2," Workshop Report, appendix IV, Monterey, CA, Naval Postgraduate School, Center on Contemporary Conflict, January 2012, 62–89.

[16] For example, see Gwyn Winfield, "Is This It?" *CBRNe World* (Summer 2009), 6–7. There have also been a number of acid attacks against girls' schools. One compilation of reported chemical attacks in Afghanistan and Iraq is "Chemical weapon terrorism in Iraq and Afghanistan," compiled by William Robert Johnston, last updated September 3, 2012, available at <www.johnstonsarchive.net/terrorism/wmdterrorism-1.html>. The accuracy of these reports is unknown.

[17] Lisa Bose McDermott, "Texas Actress Pleads Guilty for Ricin-laced Letter Sent to Obama," Reuters, December 10, 2013, available at <www.reuters.com/article/2013/12/10/us-usa-crime-ricin-idUSBRE9B90ZG20131210>.

[18] Carus, *Defining*, 42. This calculation excludes the use of poison gas in Nazi concentration camps.

[19] See "Timeline of Syrian Chemical Weapons Activity, 2012–13," Arms Control Association, available at <www.armscontrol.org/factsheets/Timeline-of-Syrian-Chemical-Weapons-Activity>.

[20] White House, "Government Assessment of the Syrian Government's Use of Chemical Weapons on August 21, 2013," August 30, 2013, available at <www.whitehouse.gov/the-press-office/2013/08/30/government-assessment-syrian-government-s-use-chemical-weapons-august-21>.

[21] Human Rights Watch, "Attacks on Ghouta," September 10, 2013, available at <www.hrw.org/reports/2013/09/10/attacks-ghouta-0>.

[22] United Nations Mission to Investigate Allegations of the Use of Chemical Weapons in the Syrian Arab Republic, "Report on the Alleged Use of Chemical Weapons in the Ghouta Area of Damascus on August 21, 2013," available at <www.un.org/disarmament/content/slideshow/Secretary_General_Report_of_CW_Investigation.pdf>.

[23] Adam Entous, Nour Malas, and Rima Abushakra, "As Syrian Chemical Attack Loomed, Serious Mishaps Doomed Civilians," *The Wall Street Journal*, November 22, 2013, available at <http://online.wsj.com/news/articles/SB10001424052702303914304579194203188283242>. According to this account, Hizballah had a specific reason for its anger at the Asad regime. Some of its soldiers, fighting in support of the regime, were operating near one of the target areas but were not warned of the attack, and some became casualties.

[24] Michael R. Gordon and Steven Lee Myers, "Obama Calls Russian Offer on Syria a Possible 'Breakthrough,'" *The New York Times*, September 9, 2013, available at <www.nytimes.com/2013/09/10/world/middleeast/kerry-says-syria-should-hand-over-all-chemical-arms.html?_r=0>.

[25] Reports of the Syrian regime's employment of chlorine gas against opponents on multiple occasions during the first half of 2014 temper the apparent victory of Syria's accession to the CWC. While chlorine is much less lethal than the nerve agents Syria has agreed to abandon, its use as an instrument of warfare would still be abhorrent and a clear violation of the CWC.

[26] The price of the Western nations' nonproliferation victory in Syria could prove to be the victory of the Syrian regime and its Iranian and Russian allies in the Syrian civil war.

[27] Neither Israel nor the United States acknowledges that Israel possesses nuclear weapons, but it is widely believed it does. While it is reported that the Israeli government hastily assembled two nuclear weapons on the eve of the 1967 war, there is also evidence that Egyptian President Gamal Abdel Nasser thought it would take Israel time to develop a weapon and in any case doubted that the Israelis would be able to employ

them. Avner Cohen, *Israel and the Bomb* (New York: Columbia University Press, 1998). By 1973, however, Egypt and Syria are much less likely to have discounted the existence of Israeli nuclear weapons, but they still invaded. Israel certainly perceived the Egyptian and Syrian invasions as an existential threat and accordingly went on nuclear alert, but Egypt and Syria apparently did not intend to drive into the heart of Israel and threaten its existence but only to seize territory lost in 1967 and then negotiate a favorable termination of hostilities. Elbridge Colby et al., *The Israeli "Nuclear Alert" of 1973: Deterrence and Signaling in Crisis* (Alexandria, VA: Center for Naval Analyses, 2013). If this in fact was Egypt and Syria's plan, it was an extraordinarily risky one, but that would be consistent with the aforementioned observation that a state's possession of nuclear weapons is useful for deterring serious threats to vital interests.

[28] The ongoing modernization and expansion of China's nuclear force, however, should afford it more counterforce and preemptive strike options if it so chooses. For a review of China's nuclear strategy, see M. Taylor Fravel and Evan S. Medeiros, "China's Search for Assured Retaliation: The Evolution of Chinese Nuclear Strategy and Force Structure," *International Security* 35, no. 2 (2010), 48–87.

[29] For a discussion of Russian nuclear doctrine, see Stephen J. Blank, "Russia and Nuclear Weapons," in *Russian Nuclear Weapons: Past, Present, and Future*, ed. Stephen J. Blank, 293–364 (Carlisle Barracks, PA: Strategic Studies Institute, 2011). For background on Pakistan's nuclear doctrine, see Feroz Hassan Khan, "Reducing the Risk of Nuclear War in South Asia," in *Pakistan's Nuclear Future: Reining in the Risk*, ed. Henry D. Sokolski, 63–101 (Carlisle Barracks, PA: Strategic Studies Institute, 2009).

[30] The 2010 Nuclear Posture Review (NPR) states that "there remains a narrow set of contingencies in which U.S. nuclear weapons may still play a role in deterring conventional or [chemical and biological weapons] attack against the United States or its allies and partners," but also indicated "[t]he United States will continue to reduce the role of nuclear weapons in deterring nonnuclear attacks." The 2010 NPR also stated unambiguously that the United States would not use or threaten to use nuclear weapons against any nonnuclear weapon state that is a party to the NPT and in compliance with its nuclear nonproliferation obligations even if such states attacked the United States with chemical or biological weapons. *Nuclear Posture Review Report* (Washington, DC: Department of Defense, April 2010), available at <www.defense.gov/npr/docs/2010%20nuclear%20posture%20review%20report.pdf>.

[31] Nuclear weapons may, however, embolden some who possess them to pursue coercion by other means in the belief that their nuclear weapons will deter an unacceptable response from the target. Pakistan may have had this in mind when it instigated what became the 1999 Kargil conflict. See, for example, S. Paul Kapur, *Nuclear Weapons, Proliferation and Conflict in South Asia* (Singapore: NUS Press, 2009), 125.

[32] Some prefer to refer to a "taboo" on the use of nuclear weapons, while others find the term "norm" too value-laden and prefer a "tradition" of nonuse of such weapons.

[33] Maurice Isserman, *The Korean War* (New York, Facts on File, Inc., 2003), 20.

[34] *Negative security assurances* refer to assurances made by nuclear-armed states not to use or threaten to use nuclear weapons against states that do not have nuclear weapons. They may be caveated; for example, current U.S. negative security assurances are extended to nonnuclear-armed states that also are in compliance with their nuclear nonproliferation obligations. For further information on negative security assurances, see Nuclear Threat Initiative, "Proposed International Legally-Binding Negative Security Assurances," available at <www.nti.org/treaties-and-regimes/proposed-internationally-legally-binding-negative-security-assurances/>.

[35] For a discussion of U.S. retaliation-only doctrine, see Jonathan B. Tucker, *War of Nerves* (New York: Anchor Books, 2006), 60, 124, 126–127, 155, 217.

[36] Beirut *Al-Akhbar Online* in English, October 14, 2013, reporting on an interview with Syrian President Bashar al-Asad.

[37] Ibid.

[38] "The United States judges that North Korea may still consider the use of biological weapons as an option, contrary to the BWC [Biological and Toxins Weapons Convention]. . . . The United States is concerned, based on information available during the reporting period, that Syria, a signatory to the BWC, may be engaged in activities that would violate its obligations under the BWC if it were a State Party to the Convention." See Department of State.

[39] In November 1995, Chechen rebels alerted the Russian press that they had buried a radiological device in a Moscow Park. A partially buried container of cesium was found where the rebels indicated. In December 1998, however, Russian security forces reported that they discovered and defused a radiological bomb near a railway outside of the Chechnya capital of Grozny. See Lexi Krock and Rebecca Dreusser, "Dirty Bomb: Chronology of Events," *NOVA*, available at <www.pbs.org/wgbh/nova/dirtybomb/chrono.html>. In June 2002, U.S. authorities arrested Jose Padilla on suspicion of planning to build and detonate a dirty bomb in a U.S city. That accusation, however, was not part of the charges brought against him in his trial, at which he was convicted of other terrorism-related crimes. See "Jury finds Padilla guilty on terror charges," *CNN.com*, August 16, 2007, available at <www.cnn.com/2007/US/08/16/padilla.verdict/index.html>.

[40] The increased casualty potential for radiological dispersion devices that disperse respirable radioactive articles in a nonexplosive way is discussed in Peter D. Zimmerman and Cheryl Loeb, *Dirty Bombs: The Threat Revisited*, Defense Horizons 38 (Washington, DC: NDU Press, January 2004).

[41] For an extended discussion of al Qaeda interest in and efforts related to WMD, see Rolf Mowatt-Larssen, *Al Qaeda Weapons of Mass Destruction Threat: Hype or Reality*

(Cambridge, MA: Belfer Center for Science and International Affairs, January 2010), available at <http://belfercenter.ksg.harvard.edu/files/al-qaeda-wmd-threat.pdf>.

[42] Danzig et al., 29–34, provides a detailed review of Aum's sarin program.

[43] Jonathan B. Tucker and Jason Pate, "Minnesota Patriots Council (1991)," in *Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons*, ed. Jonathan B. Tucker, 159–83 (Cambridge, MA: MIT Press, 2000); W. Seth Carus, *Bioterrorism and Biocrimes: The Illicit Use of Biological Agents since 1900* (Washington, DC: Center for Counterproliferation Research, 2001).

[44] Mowatt-Larssen.

[45] Concise descriptions of United Nations Security Council Resolution 1540, "The Nuclear Terrorism Convention," and other arms control and nonproliferation agreements are provided in Amy F. Woolf, Mary Beth Nitikin, and Paul K. Kerr, *Arms Control and Nonproliferation: A Catalogue of Treaties and Agreements*, RL33865 (Washington, DC: Congressional Research Service, March 7, 2012), available at <www.fas.org/sgp/crs/nuke/RL33865.pdf>.

[46] In September 2012 the U.S. Nuclear Regulatory Commission (NRC) issued the first U.S. commercial license for enriching uranium via laser isotopic separation to Global Laser Enrichment, a joint venture by General Electric and Hitachi. "Laser enrichment update: NRC issues license," *Optics.org*, September 27, 2012, available at <http://optics.org/news/3/9/34>.

[47] Oliver Tickell, "The Promise and Peril of Thorium," *WMD Junction* (Monterey, CA: James Martin Center for Nonproliferation Studies, November 5, 2012), available at <http://wmdjunction.com/121031_thorium_reactors.htm>.

[48] Mark Schneider, "The Nuclear Forces and Doctrine of the Russian Federation," U.S. Nuclear Strategy Forum, National Institute Press, publication no. 0003, 2006.

[49] Suzanne L. Jones and Frank N. von Hippel, "The Question of Pure Fusion Explosions under the CTBT," *Science & Global Security* 7, no. 2 (1998), 129–150.

[50] Geoff Brumfiel, "Scientists Say Their Giant Laser Has Produced Fusion Energy," *National Public Radio*, February12, 2014, available at <www.npr.org/blogs/thetwo-way/2014/02/12/275896094/scientists-say-their-giant-laser-has-produced-nuclear-fusion>.

[51] These conclusions are not materially different than those in Committee on Advances in Technology and the Prevention of Their Application to Next Generation Biowarfare Threats, National Research Council, *Globalization, Biosecurity, and the Future of the Life Sciences* (Washington, DC: National Academies Press, 2006).

[52] For a useful review, see Jonathan B. Tucker and Raymond A. Zilinskas, "The Promise and Perils of Synthetic Biology," *The New Atlantis*, no. 12 (2006), 25–45.

[53] Many of these developments are discussed in the "Report on the Scientific Advisory Board on Developments in Science and Technology for the Third Special

Session of the Conference of the States Parties to Review the Operation of the Chemical Weapons Convention," RC-3/DG.1, Organisation for the Prohibition of Chemical Weapons, October 29, 2012, available at <www.opcw.org/index.php?eID=dam_frontend_push&docID=15865>.

[54] Mark L. Wheelis, "Biotechnology and Biochemical Weapons," *The Nonproliferation Review* 9, no. 1 (2002), 48–53.

[55] The international community has discussed this issue for more than 30 years. Jerzy Zaleski concisely summarizes the ultimately unproductive multidecade effort to define and ban new types of WMD as follows: "The history of the consideration of the item 'New types of weapons of mass destruction and new systems of such weapons' shows how the original list of weapons that could have effects comparable to those of acknowledged weapons of mass destruction (nuclear, chemical and biological) became shorter and shorter, as technical problems with weaponization of some proposed phenomena with potential military application led to the questioning of their military effectiveness. After decades of consideration of the item, only radiological weapons remain on the agenda of the Conference [of the Committee on Disarmament] although, paradoxically, there seems to be no serious interest in the Conference to negotiate a ban on such weapons." See Zaleski, 9.

[56] Vladimir Putin, "Being Strong: National Security Guarantees for Russia," *Rossiiskaya Gazeta*, February 20, 2012, available at <http://archive.premier.gov.ru/eng/events/news/18185//>.

[57] Studies consulted included U.S. National Intelligence Council, *Global Trends 2030: Alternative Worlds*, December 2012, available at <www.dni.gov/index.php/about/organization/national-intelligence-council-global-trends>; European Union Institute for Security Studies, *Global Trends 2030: Citizens in an Interconnected and Polycentric World*, 2011, available at <www.iss.europa.eu/publications/detail/article/espas-report-global-trends-2030-citizens-in-an-interconnected-and-polycentric-world/>; U.S. Joint Forces Command, *The Joint Operating Environment 2010*, February 10, 2010, available at <www.jfcom.mil/newslink/storyarchive/2010/JOE_2010_o.pdf>; United Kingdom Ministry of Defence, Director General, Concepts and Doctrine (DCDC), *Global Strategic Trends—Out to 2040*, Strategic Trends Programme, 4th ed., January 12, 2010, available at <www.mod.uk/NR/rdonlyres/6AAFA4FA-C1D3-4343-B46F-05EE80314382/0/GST4_v9_Feb10.pdf>; UK Ministry of Defence, DCDC, *Future Character of Conflict*, available at <www.mod.uk/DefenceInternet/MicroSite/DCDC/OurPublications/Concepts/FutureCharacterOfConflict.htm>; UK Ministry of Defence, DCDC, *The Future Land Operational Concept 2008*, 2008, available at <www.scribd.com/doc/32871896/UK-MOD-Future-Land-Operational-Concept>; The Netherlands Ministry of Defence, *Future Policy Survey: A New Foundation for the Netherlands Armed Forces*, 2010, available at <www.deruijter.net/uk/wp-content/uploads/article-Ministry-of-Defence.pdf>; Canadian Department of National Defence, *The Future Security Environment 2008–2030*, January 27, 2009, available

at <www.cfd-cdf.forces.gc.ca/documents/CFD%20FSE/Signed_Eng_FSE_10Jul09_eng.pdf>; and International Energy Agency, *World Energy Outlook 2012*, Executive Summary, available at <www.iea.org/publications/freepublications/publication/name,33339,en.html>. We also met with experts from the following think tanks during February 2012: Center for International Security and Cooperation, Stanford University, Palo Alto, CA; Monterey Institute for International Studies, Middlebury University, Monterey, CA; and Center for Science, Technology and Policy, University of New Mexico, Albuquerque, NM.

[58] U.S. National Intelligence Council, *Global Trends 2030—Alternative Worlds*, iv.

[59] Ibid., 9.

[60] Ibid., iv.

[61] European Union Institute for Security Studies, 20.

[62] UK Ministry of Defence, DCDC, *Future Character of Conflict*, 31.

[63] U.S. National Intelligence Council, *Global Trends 2030—Alternative Worlds*, 48.

[64] European Union Institute for Security Studies, 129–137.

[65] UK Ministry of Defence, Director General, Concepts and Doctrine (DCDC), *Global Strategic Trends—Out to 2040*, 17.

[66] U.S. National Intelligence Council, *Global Trends 2030—Alternative Worlds*, 71.

[67] Gregg Easterbrook, "The End to War?" *New Republic* 232, no. 20 (2005), 18–21. A longer exposition of this thesis is Steven Pinker, *The Better Angels of Our Nature: Why Violence Has Declined* (New York: Viking, 2011).

[68] Focusing on the Cold War confrontation, John Lewis Gaddis, "The Long Peace: Elements of Stability in the Postwar International System," *International Security* 10, no. 4 (1986), 99–142, pointed to nuclear arsenals, the inherent stability of bipolar international systems, the absence of conflicts over resources between the competing blocs, the muting of the ideological dimension of the contest, limited domestic pressures promoting confrontation, and the positive effect of what he called the "reconnaissance revolution." More recently, the Human Security Report Project, *Human Security Report 2009/2010* (New York: Oxford University Press, 2011), observed, "While the diversity of possible explanations for the decline in international conflict complicates the task of analysis, the fact that the Long Peace between the major powers is supported by so many different pillars almost certainly helps account for its durability." Human Security Report Project, *Human Security Report 2009/2010*, 3.

[69] Human Security Report Project, 3. Possible explanations include theories that liberal democracies rarely fight one another, globalization makes countries increasingly economically interdependent, the costs of conducting wars exceeds their perceived economic benefits, the growth of antiwar ideas and the decline of militaristic ideologies make war less attractive to political elites, the growth of multinational organizations has created conditions that make war less likely, the growing intensity of mediation activities makes settlements more likely (even if temporary), the decline in the number of countries

with youthful populations reduces a characteristic correlated with instability and conflict, and international alliances (especially the security architecture organized by the United States, supported by its nuclear deterrence) provide a protective shield against aggression for many countries.

[70] Monty G. Marshall and Benjamin R. Cole, *Global Report 2011: Conflict, Governance, and State Fragility* (Fairfax, VA: Center for Global Policy, School of Public Policy, George Mason University, and the Center for Systemic Peace, 2011), 4.

[71] Hydraulic fracturing (fracking) and horizontal drilling technologies are already enabling the exploitation of gas and oil deposits in shale formations and other difficult or remote locations. The melting of Artic sea ice, a function of climate change, is expected to open up access to large oil and gas deposits beneath the Arctic Ocean. Technology has driven the dramatic expansion of global agricultural output over the last half century.

[72] U.S. National Intelligence Council, *Global Trends 2030—Alternative Worlds*, viii.

[73] Ibid., 36.

[74] Ibid., 50.

[75] Erik Gartzke, "Could Climate Change Precipitate Peace?" *Journal of Peace Research* 49, no. 1 (2012), 177–192. A critique of the "water causes war" thesis is offered by Wendy Barnaby, "Do Nations Go to War over Water?" *Nature* 458, no. 7236 (2009), 282–283. For a pessimistic view offered two decades ago, see Peter H. Gleick, "Water and Conflict: Fresh Water Resources and International Security," *International Security* 18, no. 1 (1993), 79–112.

[76] U.S. National Intelligence Council, *Global Trends 2030—Alternative Worlds*, 13, 15.

[77] UK Ministry of Defence, *Global Strategic Trends—Out to 2040*, 129.

[78] European Union Institute for Security Studies, 13.

[79] UK Ministry of Defence, *Global Strategic Trends—Out to 2040*, 15.

[80] European Union Institute for Security Studies, 13.

[81] U.S. Joint Forces Command, 58–59.

[82] UK Ministry of Defence, *Global Strategic Trends—Out to 2040*, 16.

[83] The classic examples are South Korea and Taiwan. Both countries, reliant on U.S. security guarantees, had nuclear weapons programs cancelled under pressure from Washington. See Hersman and Peters, 539–553.

[84] A study by the State Department's International Security Advisory Board, *Report on Discouraging a Cascade of Nuclear Weapons States*, October 19, 2007, 9, explicitly notes, "the states involved in a possible cascade—Japan, South Korea, Taiwan, Turkey, Saudi Arabia, Egypt, Brazil, etc.—would not be rogue states," available at <http://2001-2009.state.gov/documents/organization/95786.pdf>.

[85] Defense Science Board, *Assessment of Nuclear Monitoring and Verification Technologies* (Washington, DC: Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, January 2014).

[86] Department of State, "Adherence to and Compliance with Arms Control, Nonproliferation, and Disarmament Agreements and Commitments, July 2013," 12–13.

[87] They stress that the Chemical Weapons Convention (CWC) is an arms control treaty and should concentrate on disarmament until all chemical weapons (CW) possessor states are CWC members and all CW are destroyed. This inflexible position has made it difficult for the Organisation for the Prohibition of Chemical Weapons to meaningfully address nonproliferation issues such as terrorism or improving the efficacy of industry inspections.

[88] For example, "Redoubling our efforts to resolve regional confrontations and conflicts that give rise to new nuclear powers" is one of the "urgent" steps toward elimination identified in Shultz et al. Article VI of the NPT also couches the States Parties' obligation to work toward the abolishment of their nuclear weapons in the context of "general and complete disarmament."

[89] Mark McDonald, "North Korea Suggests Libya Should Have Kept Nuclear Program," *The New York Times*, March 24, 2011, available at <www.nytimes.com/2011/03/25/world/asia/25korea.html>.

[90] Even nonstate groups such as Hizballah or Hamas should be able to construct a nuclear device given access to fissile material, according to the expert evaluation in Carson Mark et al., "Can Terrorists Build Nuclear Weapons?" in *Preventing Nuclear Terrorism: The Report and Papers of the International Task Force on Prevention of Nuclear Terrorism*, ed. Paul Leventhal and Yonah Alexander, 55–65 (Lexington, MA: Lexington Books, 1987). Some experts remain skeptical that any terrorist group could or would, as articulated in Brian Michael Jenkins, *Will Terrorists Go Nuclear?* (Amherst, NY: Prometheus Books, 2008).

[91] South Korea seeks Washington's agreement to revise their bilateral Section 123 agreement on civilian nuclear cooperation to authorize South Korea's utilization of its "pyro-processing" technology, which the United States considers a plutonium reprocessing technology. The current 123 agreement prohibits South Korea from reprocessing plutonium or enriching uranium. The United States and South Korea recently agreed to extend the existing agreement for 2 more years to permit time to resolve this issue.

[92] Putin.

[93] See "The Moscow Theater Hostage Crisis: Incapacitants and Chemical Warfare," James Martin Center for Nonproliferation Studies, n.d., available at <http://cns.miis.edu/stories/02110b.htm>, for a discussion of the Moscow theater hostage crisis.

[94] Similarly, the international reaction to reports of the Syrian regime's employment of chlorine gas against opponents on multiple occasions during the first half of 2014 has been limited as none of those incidents has been associated with large-scale fatalities.

[95] The influential and timely Human Rights Watch (HRW) report, "Attacks of Ghouta," drew heavily on the extensive social media accounts of the attacks, as HRW representatives explained at a workshop at National Defense University January 10, 2014.

[96] Within the United States, the Environmental Protection Agency, National Nuclear Security Administration (NNSA), and Nuclear Regulatory Commission have programs to reduce the dangers from radiological materials, including through recovering orphaned and no longer needed radiological sources, by ensuring accountability for radiological materials, and developing substitutes for radioactive isotopes deemed particularly dangerous. NNSA also works with other countries to achieve the same objectives.

[97] That at least some terrorist groups might see an advantage in possessing but not using a nuclear weapon is suggested by Lewis A Dunn, *Can Al Qaeda Be Deterred from Using Nuclear Weapons?* (Washington, DC: NDU Press, 2005).

[98] Martin Shubik, "Terrorism, Technology, and the Socioeconomics of Death," *Comparative Strategy* 16, no. 4 (1997), 399–415.

[99] Current U.S. policy excludes any nuclear response in the event of biological or chemical weapons use but explicitly leaves open the possibility of reevaluating this policy for biological weapons. See Department of Defense, 16.

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