

**Bulletin
of the
Atomic
Scientists**

**At doom's doorstep:
It is 100 seconds to midnight**

2022 Doomsday Clock Statement

Science and Security Board
Bulletin of the Atomic Scientists

Editor, John Mecklin

**IT IS 100 SECONDS
TO MIDNIGHT**



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Editor's note: Founded in 1945 by Albert Einstein and University of Chicago scientists who helped develop the first atomic weapons in the Manhattan Project, the Bulletin of the Atomic Scientists created the Doomsday Clock two years later, using the imagery of apocalypse (midnight) and the contemporary idiom of nuclear explosion (countdown to zero) to convey threats to humanity and the planet. The Doomsday Clock is set every year by the Bulletin's Science and Security Board in consultation with its Board of Sponsors, which includes 11 Nobel laureates. The Clock has become a universally recognized indicator of the world's vulnerability to catastrophe from nuclear weapons, climate change, and disruptive technologies in other domains.

To: **Leaders and citizens of the world**

Re: **At doom's doorstep: It is 100 seconds to midnight**

Date: **January 20, 2022**

Last year's leadership change in the United States provided hope that what seemed like a global race toward catastrophe might be halted and—with renewed US engagement—even reversed. Indeed, in 2021 the new American administration changed US policies in some ways that made the world safer: agreeing to an extension of the New START arms control agreement and beginning strategic stability talks with Russia; announcing that the United States would seek to return to the Iran nuclear deal; and rejoining the Paris climate accord. Perhaps even more heartening was the return of science and evidence to US policy making in general, especially regarding the COVID-19 pandemic. A more moderate and predictable approach to leadership and the control of one of the two largest nuclear arsenals of the world marked a welcome change from the previous four years.

Still, the change in US leadership alone was not enough to reverse negative international security trends that had been long in developing and continued across the threat horizon in 2021.

US relations with Russia and China remain tense, with all three countries engaged in an array of nuclear modernization and expansion efforts—including China's apparent large-scale program to increase its deployment of silo-based long-range nuclear missiles; the push by

Russia, China, and the United States to develop hypersonic missiles; and the continued testing of anti-satellite weapons by many nations. If not restrained, these efforts could mark the start of a dangerous new nuclear arms race. Other nuclear concerns, including North Korea's unconstrained nuclear and missile expansion and the (as yet) unsuccessful attempts to revive the Iran nuclear deal contribute to growing dangers. Ukraine remains a potential flashpoint, and Russian troop deployments to the Ukrainian border heighten day-to-day tensions.

For many countries, a huge gap still exists between long-term greenhouse gas-reduction pledges and the near- and medium-term **emission-reduction actions** needed to achieve those goals. Although the new US administration's quick return to the Paris Agreement speaks the right words, it has yet to be matched with actionable policies.

Developed countries improved their responses to the continuing COVID-19 pandemic in 2021, but the worldwide response remained entirely insufficient. Plans for quick global distribution of vaccines essentially collapsed, leaving poorer countries largely unvaccinated and allowing new variants of the SARS-CoV-2 virus to gain an unwelcome foothold. Beyond the pandemic, worrying biosafety and biosecurity lapses made it clear that the international community needs to focus serious attention on management of the global biological research enterprise. Further, the establishment and pursuit of biological

weapons programs marked the beginning of a new biological arms race.

And while the new US administration made progress in reestablishing the role of science and evidence in public policy, corruption of the information ecosystem continued apace in 2021. One particularly concerning variety of internet-based disinformation infected America last year: Waves of internet-enabled lies persuaded a significant portion of the US public to believe the utterly false narrative contending that Joe Biden did not win the US presidential election in 2020. Continued efforts to foster this narrative threaten to undermine future US elections, American democracy in general, and, therefore, the United States' ability to lead global efforts to manage existential risk.

In view of this mixed threat environment—with some positive developments counteracted by worrisome and accelerating negative trends—the members of the Science and Security Board find the world to be no safer than it was last year at this time and therefore decide to set the Doomsday Clock once again at 100 seconds to midnight. This decision does not, by any means, suggest that the international security situation has stabilized. On the contrary, the Clock remains the closest it has ever been to civilization-ending apocalypse because the world remains stuck in an extremely dangerous moment. In 2019 we called it the new abnormal, and it has unfortunately persisted.

Last year, despite laudable efforts by some leaders and the public, negative trends in nuclear and biological weapons, climate change, and a variety of disruptive technologies—all exacerbated by a corrupted information ecosystem that undermines rational decision making—kept the world

within a stone's throw of apocalypse. Global leaders and the public are not moving with anywhere near the speed or unity needed to prevent disaster.

Leaders around the world must immediately commit themselves to renewed cooperation in the many ways and venues available for reducing existential risk. Citizens of the world can and should organize to demand that their leaders do so—and quickly. The doorstep of doom is no place to loiter.

The nuclear tightrope

During 2021, some nuclear risks declined while others rose. Upcoming decisions on nuclear policies could generate either salutary or dangerous modifications of an already uncertain and worrisome security situation.

The February 2021 agreement between the United States and Russia to renew New START for five years is a decidedly positive development. This extension creates a

window of opportunity to negotiate a future arms control agreement between the two countries that possess 90 percent of the nuclear weapons on the planet. The United States and Russia also agreed to start two sets of dialogues about how to best maintain “nuclear stability” in the future: the Working Group on Principles and Objectives for Future Arms Control and the Working Group on Capabilities and Actions with Strategic Effects. These groups have met and in early 2022 are expected to report on initial results of the consultations, aimed at shaping future arms control agreements.

Another bright spot was the Biden administration's announcements that it would seek to return to the Joint Comprehensive Plan of Action (JCPOA) with Iran and offer to enter strategic stability talks with China. Although

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no talks between North Korea and the United States took place in 2021, the North Koreans have not resumed testing of nuclear weapons or long-range intercontinental ballistic missiles (ICBMs). (Tests of shorter-range missiles have continued.) Finally, when the Biden administration began its Nuclear Posture Review (NPR) process, it announced that one specific goal would be to “reduce the role of nuclear weapons” in US national security policy.

Other developments, however, appeared on the negative side of the ledger:

Iran continues to build an enriched uranium stockpile, insisting that all sanctions be removed before returning to talks with the United States on the JCPOA. The window of opportunity seems to be closing. Over time, Iran's neighbors, particularly Saudi Arabia, may feel compelled to acquire similar capabilities, foreshadowing the frightening possibility of a Middle East with multiple countries with the expertise and material to build nuclear weapons.

The Chinese have started to build new ICBM silos on a large scale, leading to concerns that China may be considering a change in its nuclear doctrine. China and Russia have both tested anti-satellite weapons recently, increasing concerns about rapid escalation in any conventional conflict with the United States. Efforts by all three countries to field hypersonic missiles are beginning to yield results, intensifying competition. While experts disagree on both the causes and the consequences of these programs, they clearly mark the start of a new arms competition.

The North Koreans continue to test nuclear-capable short- and medium-range missiles,

including cruise, ballistic, and glide vehicles, and there is evidence of their restarting plutonium production. Meanwhile, there have been no high-level negotiations between the United States and North Korea. India and Pakistan continue to advance their nuclear, missile, and other military capabilities with no diminution of possible flash points that could lead to nuclear conflict.

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As the January 6, 2021 insurrection at the US Capitol demonstrated, no country is immune from threats to its democracy, and in a state with nuclear-weapons-usable material and nuclear weapons, both can be targets for terrorists and fanatics. Notably, the insurrectionists came close to capturing Vice President Mike Pence and the “nuclear football” that accompanies the vice president as the backup system for nuclear launch commands. **More than 10**

percent of those charged with crimes during the January 6th insurrection were veterans or active service members. The Pentagon has conducted a major review of extremism in the military and has adopted new definitions of extremist activities in an attempt to reduce this danger in the future. The seriousness of the problem is clear.

Finally, the United States is preparing a Nuclear Posture Review to guide US strategy, policy, and deployments of nuclear weapons, but its overall message appears not yet decided. We hope the document will assert that the United States will reduce the role of nuclear weapons in its deterrence and defense policies, which in turn may positively affect the nuclear weapons postures of other countries, leading, we believe, to a safer world. Where we set the Clock next year will be influenced by what the Nuclear Posture

Review ultimately contains. Reports of congressional interference in the process, resulting in the firing of personnel conducting the review, suggests unwelcome politicization that could well affect the outcome and make more rational nuclear weapons policies hard to effect.

Climate change: Lots of words, relatively little action

This past year's climate negotiations in Glasgow marked an important milestone in climate multilateralism: a critical first round of the treaty's cycle of upgrading national efforts. Countries were under pressure to strengthen their emission-reduction pledges significantly relative to their pledges six years ago in Paris. The results, unfortunately, were insufficient. China and India affirmed that they would move away from use of coal, but only gradually; they affirmed for the first time the objective of achieving "net zero," but only in 2060 and 2070, respectively. There was only partial progress toward defined accounting rules to allow international markets for greenhouse gas emissions and removals to develop. Developed countries again failed to follow through on treaty commitments to provide necessary financial and technological support. Overall, countries' projections and plans for **fossil fuel production are far from adequate** to achieve the global Paris goals to limit the warming of the surface of the planet to "well below two degrees Celsius" (3.6 degrees Fahrenheit) relative to the temperature around 1800, at the beginning of the industrial revolution.

Encouragingly, **several countries** (as well as **financial institutions** and **corporations**) have announced a commitment to achieve net-zero

carbon dioxide emissions for the long term—meaning by 2050 or thereabouts. These announcements are significant, in that reaching zero aggregate carbon dioxide emissions globally would halt the buildup of greenhouse gas pollution in the atmosphere, which is absolutely critical to halting yet more warming. Earnest efforts to reach these seemingly distant targets require concerted actions in the immediate term, including a redirection of investment away from the production and use of fossil fuel and toward renewables and energy efficiency, massive upgrading of existing infrastructure, and a shift in land use and agriculture practices. The real test of the significance of these net-zero pledges will be whether they are matched by near- and medium-term **emission-reduction actions**.

Efforts to reach seemingly distant climate targets require concerted actions in the immediate term.

Last year, we noted optimistically the election of a US president who "acknowledges climate change as a profound threat and supports international cooperation and science-based policy," and we've seen a dramatic change in tone from the previous presidential administration. Recognizing that "[t]he effects we are seeing of climate change are the crisis of our generation," **Biden has indeed**

attempted to move forward quickly, reentering the United States in the Paris Agreement and announcing the United States' **updated Paris emission pledge** of a 50 percent reduction by 2030. He has also signaled an attentiveness to the connection between climate action and environmental justice, in both the domestic and international contexts. He has **committed to making climate investments** in disadvantaged communities within the United States, and at the UN General Assembly meeting **he pledged to double climate financing** to developing countries.

However, progress achievable through the US political process is highly constrained and fragile, as any subsequent president may try to swing the pendulum backward. The major infrastructure package passed in 2021 is less of a “climate bill” than the Biden administration initially proposed, and the fate of the climate goals of the “Build Back Better” bill hangs in the balance of a starkly divided Congress. It thus is not yet clear how much progress the United States will make in the coming year toward its announced emissions reduction pledge and finance promise.

For over four decades the threat of climate change to “future generations” has been ruefully noted. As warming has continued to drive up temperatures—from an unprecedented extreme high temperature of **100 degrees Fahrenheit in the Siberian Arctic** to the record-breaking **2021 “heat dome” over western Canada and the United States**—today’s young people are increasingly seeing themselves as the future victims. They are witnessing human and ecosystem tragedies caused, for example, by **droughts in eastern Africa** and the **United States**, **floods in China** and **Europe**, and **wildfires raging around the world**, **harbingers** of yet more dire consequences as climate change accelerates in their lifetimes.

The experience of a deepening crisis has animated protests and other civil society expressions of alarm this year. These have occurred at major political events (such as the **G7 Summit**), by youth climate movements (such as the student-led **Fridays for Future** protests around the world), at September’s **Climate Week** in New York, at **COP26 in Glasgow**, and at individual sites of proposed new fossil fuel infrastructure (such as Line 3 in the United States, the Trans Mountain Pipeline

in Canada, and the EACOP pipeline in Uganda and Tanzania). These actions focus public attention on climate change and raise its political salience, but whether they will transform policies, investments, and behaviors remains among the most important questions facing global society.

The burgeoning biological threat to civilization

For years, the United States and many other countries underinvested in defense against natural, accidental, and intentional biological threats. They also underestimated the impacts that a biological threat could have on the

entire world. COVID-19 revealed vulnerabilities in every country and the world’s collective ability to prepare for, respond to, and recover from infectious disease outbreaks.

The COVID-19 pandemic rightly has absorbed the world’s attention, given its demonstrated ability to sicken and kill millions, weaken national economies and global supply chains, and destabilize governments and societies. And yet,

what the world has experienced during this pandemic is nowhere close to a worst-case scenario.

To deal with the crisis at hand, the world is focusing almost all its efforts on COVID-19, to the exclusion of other biological threats. The scope of potential biological threats is expansive. Preventing and mitigating future biological events will require a wider lens for viewing biological threats. For example, slow vaccination rates have allowed virus mutations, perpetuating the threat from COVID-19. Similarly, failing to address antibiotic resistance could trigger a worldwide

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pandemic involving antimicrobial-resistant organisms within a decade. Research into novel diseases has proliferated high-containment laboratories around the world. Some of those labs inadvertently release pathogens into the environment. Some regimes to monitor and regulate these laboratories are perceived by their researchers to be excessively burdensome and restrictive. At the same time, the Biological Weapons and Toxin Convention still struggles to find effective ways to enforce its prohibitions on the development and production of biological agents and weapons.

This year, the US Department of State declared that Russia and North Korea possess active biological weapons programs and expressed concern about dual-use biological research programs in China and Iran. Terrorist organizations such as Al Qaeda and ISIS and some criminal organizations continue to profess their determination to build, acquire, and use biological weapons to achieve their goals. The globally inadequate response to COVID-19 only serves to underscore that an attack using a weapon containing biological agents designed to resist existing medical countermeasures could provide attackers with some of the tactical, operational, strategic, and economic advantages they seek. The US Department of Defense is now concerned enough about that prospect to undertake a biological posture review.

The world now lives in an age of biological innovation. Many countries and corporations are making enormous investments in biological science, biotechnology, and combinational science and technology (in which biology combines with other fields), recognizing that they have immense opportunities to establish and grow bio-economies. Innovative biological research and development efforts simultaneously increase and decrease biological risk. The field is moving quickly.

CRISPR-Cas9, the revolutionary genetic engineering tool that scientists in the United

States and Sweden discovered in 2012, is cheap and ubiquitous today, spurring investments in genetic testing and adult stem cell technologies. Countries and non-state actors are exploring ways to create super-soldiers, personalize medicine, increase human performance, improve human gene therapy, and synthesize biology. Innovations such as synthetic biology have created new areas of discovery, outpacing current public health, safety, and security measures.

The world is failing to recognize the multifaceted nature of the biological threat. Advances in biological science and technology can harm us as well as help us. Leaders must recognize that COVID-19 is not the last biological threat we will have to face in our lifetimes—or, perhaps, even this year.

Disruptive technology in the age of disinformation

The new US administration has done much to reestablish the role of scientists in informing public policy, and even more to minimize deliberate confusion and chaos emanating from the White House. Thoughtful deliberation—merely a promise in January 2021—appears to be realized more often today. On the other hand, disinformation fomented outside the executive branch—including from some members of Congress and many state leaders—appears to have taken root in alarming and dangerous ways.

Large fractions of Congress and the public continue to deny that Joe Biden legitimately won the presidential election, and their views on these matters appear to be hardening rather than moderating. Similar trends regarding COVID-related disinformation are apparent around the world, crippling the ability of public health authorities and medical science to achieve higher vaccination rates. Mask-wearing and social distancing are similarly discouraged by disinformation. While we know more now about the role of social media campaigns in taking advantage of vulnerabilities in human psychology and

cognition to spread disinformation and societal disunity, the behavior of social media companies has changed hardly at all. Political attacks on institutions that provide societal continuity and store hard-won knowledge about how best to deal with problems continue apace.

In cyber conflict, cyberattackers have grown more audacious. The SolarWinds hack, an attack on Microsoft Exchange that affected millions around the world, and a ransomware attack on Colonial Pipeline (resolved only with the payment of \$4.4 million to get the system up and running again) all demonstrate the far-reaching ramifications of cyber-vulnerabilities.

The good news in cyber includes a Biden executive order and other federal government initiatives on cybersecurity that seem to have significant force and momentum behind them and have gone farther than previous orders and initiatives. The expert cybersecurity team the new administration has assembled has the ear of the president. In addition, against all odds, both the UN **Open-Ended Working Group** and the **Group of Government Experts** have reached some rough consensus on cyber norms of behavior. (The first group involves representatives from most of the world's nations; the latter includes the biggest players in cyber.) It remains to be seen whether these norms actually affect the behavior of national actors in cyberspace, but it is better to have these norms in place (or in the process of being formed and agreed to) than not to have them at all.

It also appears that Chinese use of surveillance technology has reached new heights in Xinjiang in the last year. Artificial intelligence and facial recognition systems intended to reveal states of emotion have been **tested on Uyghurs** in Xinjiang. In the last year, it has also come to light that China is seeking to **develop standards for using facial recognition** that can be optimized for distinguishing individuals by ethnic group. The potential widespread deployment of these technologies presents a

distinct threat to human rights around the world and, therefore, civilization as we know and practice it.

Finally, tensions over military space activity have increased in the past few years. For example, Russia conducted an anti-satellite missile test in November, destroying one of its own satellites and creating a debris cloud that orbited dangerously close to the International Space Station. Russia has also “injected an object into orbit” that subsequently approached another

Russian satellite already in orbit in a manner consistent with its use as **an anti-satellite weapon**. A similar activity has been used to follow a **US government satellite**. Press reports have suggested that US Space Command is on the verge of disclosing **a new anti-satellite weapon**. On the other hand, US officials from the State and Defense departments were reported to be drafting language for **a binding UN resolution** regarding responsible behavior in space. If approved, such language could reduce the likelihood of space incidents taking place.

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Practical steps to move the world away from catastrophe and toward a safer world

Last year, we looked forward to the end of the COVID-19 pandemic—but that end is not yet in sight. Leaders in the wealthiest and most advanced countries have not acted with the speed and focus necessary to manage dire threats to humanity's future.

Our decision to keep the Doomsday Clock at 100 seconds to midnight is a clear warning to the world: We need to back away from the doorstep of doom. Immediate, practical steps to protect humanity from the major global threats that we have outlined are needed:

- The Russian and US presidents should identify more ambitious and comprehensive limits on nuclear weapons and delivery systems by the end of 2022. They should both agree to reduce reliance on nuclear weapons by limiting their roles, missions, and platforms, and decrease budgets accordingly.
- The United States and other countries should accelerate their decarbonization, matching policies to commitments. China should set an example by pursuing sustainable development pathways—not fossil fuel-intensive projects—in the Belt and Road Initiative.
- US and other leaders should work through the World Health Organization and other international institutions to reduce biological risks of all kinds through better monitoring of animal-human interactions, improvements in international disease surveillance and reporting, increased production and distribution of medical supplies, and expanded hospital capacity.
- The United States should persuade allies and rivals that no-first-use of nuclear weapons is a step toward security and stability and then declare such a policy in concert with Russia (and China).
- President Biden should eliminate the US president's sole authority to launch nuclear weapons and work to persuade other countries with nuclear weapons to put in place similar barriers.
- Russia should rejoin the NATO-Russia Council and collaborate on risk-reduction and escalation-avoidance measures.
- North Korea should codify its moratorium on nuclear tests and long-range missile tests and help other countries verify a moratorium on enriched uranium and plutonium production.
- Iran and the United States should jointly return to full compliance with the Joint Comprehensive Plan of Action and initiate new, broader talks on Middle East security and missile constraints.
- Private and public investors should redirect funds away from fossil fuel projects to climate-friendly investments.
- The world's wealthier countries should provide more financial support and technology cooperation to developing countries to undertake strong climate action. COVID-recovery investments should favor climate mitigation and adaptation objectives across all economic sectors and address the full range of potential greenhouse gas emission reductions, including capital investments in urban development, agriculture, transport, heavy industry, buildings and appliances, and electric power.
- National leaders and international organizations should devise more effective regimes for monitoring biological research and development efforts.
- Governments, technology firms, academic experts, and media organizations should

cooperate to identify and implement practical and ethical ways to combat internet-enabled misinformation and disinformation.

- At every reasonable opportunity, citizens of all countries should hold their local, regional, and national political officials and business and religious leaders accountable by asking “What are you doing to address climate change?”

Without swift and focused action, truly catastrophic events—events that could end civilization as we know it—are more likely. When the Clock stands at 100 seconds to midnight, we are all threatened. The moment is both perilous and unsustainable, and the time to act is now. 🌱

Science and Security Board Biographies

Rachel Bronson is the President and CEO of the Bulletin of the Atomic Scientists, where she oversees the publishing programs, the management of the Doomsday Clock, and activities around nuclear risk, climate change, and disruptive technologies. Before joining the Bulletin, she served as vice president for Studies at The Chicago Council on Global Affairs, adjunct professor of “Global Energy” at the Kellogg School of Management, and senior fellow and director of Middle East studies at the Council on Foreign Relations, among other positions. Her book, *Thicker than Oil: America’s Uneasy Partnership with Saudi Arabia* (Oxford University Press, 2006), has been translated into Japanese and published in paperback. Her writings and commentary have appeared in outlets including *Foreign Affairs*, *Foreign Policy*, *The New York Times*, *The Washington Post*, “PBS NewsHour,” and “The Daily Show.” Bronson has served as a consultant to NBC News and testified before the congressional Task Force on Anti-Terrorism and Proliferation Financing, Congress’s Joint Economic Committee, and the 9/11 Commission.

Edmund G Brown Jr. (Executive Chair)

completed his fourth term as Governor of the State of California in 2019. He began his career in public service in 1969 as a trustee for the LA Community College District and became California Secretary of State in 1970 and Governor of California in 1974 and 1978. After his governorship, Brown lectured and traveled widely, practiced law, served as chairman of the state Democratic Party, and ran for president. Brown was elected Mayor of Oakland in 1998 and California Attorney General in 2006; he was elected to a third gubernatorial term in 2010 and a fourth term in 2014. During this time, Brown helped eliminate the state's multi-billion budget deficit, spearheaded successful campaigns to provide new funding for California's schools, and established a robust Rainy Day Fund to prepare for the next economic downturn. His administration established nation-leading targets to protect the environment and fight climate change. Brown attended the University of California, Berkeley, and earned a JD at Yale Law School.

Lynn Eden Eden is Senior Research Scholar (Emeritus) at Stanford University’s Center for International Security and Cooperation. Eden is also co-chair of US Pugwash and a member of the International Pugwash Council. Her scholarly work focuses on the military and society; science, technology, and organizations; and US nuclear weapons history and policy. Eden’s *Whole World on Fire: Organizations, Knowledge, and Nuclear Weapons Devastation* won the American Sociological Association’s 2004 Robert K. Merton award for best book in science and technology studies. Her current research and writing asks how a specific US military planning organization has enabled very good people to plan what, if put into action, could or would result in the deaths of tens or hundreds of millions of people. In other words, how do US military officers make plans to fight and prevail in nuclear war? The answer lies not in individual psychology but in common organizational processes such as abstraction, categorization, and fragmented responsibilities.

Rod Ewing is the Frank Stanton Professor in Nuclear Security in the Center for International Security and Cooperation in the Freeman Spogli Institute for International Studies and a Professor in the Department of Geological Sciences in the School of Earth, Energy and Environmental Sciences at Stanford University. Ewing’s research focuses on the back end of the nuclear fuel cycle, mainly nuclear materials and the geochemistry of radionuclides. He is the past president of the International Union of Materials Research Societies. Ewing has written extensively on issues related to nuclear waste management and is co-editor of *Radioactive Waste Forms for the Future* and *Uncertainty Underground: Yucca Mountain and the Nation’s High-Level Nuclear Waste*. He received the Lomonosov Medal of the Russian Academy of Sciences in 2006.

Steve Fetter is associate provost, dean of the graduate school, and professor of public policy at the University of Maryland. He served for five years in the White House Office of Science and Technology Policy during the Obama Administration, where he led the environment and energy and the national security and international

Biographies (cont.)

affairs divisions. He is a fellow of the American Physical Society and a member of the Union of Concerned Scientists board of directors and the National Academy of Sciences Committee on International Security and Arms Control. He has worked on nuclear policy issues in the Pentagon and the State Department and has been a visiting fellow at Stanford, Harvard, MIT, and Lawrence Livermore National Laboratory. He also served as associate director of the Joint Global Change Research Institute and vice chairman of the Federation of American Scientists. He is a recipient of the American Physical Society's Joseph A. Burton Forum and Leo Szilard Lectureship awards, the Federation of American Scientists' Hans Bethe 'Science in the Public Service' award, and the Secretary of Defense Medal for Outstanding Public Service.

Asha M. George is the executive director of the Bipartisan Commission on Biodefense. She is a public health security professional whose research and programmatic emphasis has been practical, academic, and political. George served in the US House of Representatives as a senior professional staffer and subcommittee staff director at the House Committee on Homeland Security in the 110th and 111th Congress. She has worked for a variety of organizations, including government contractors, foundations, and non-profits. As a contractor, she supported and worked with all federal Departments, especially the Department of Homeland Security and the Department of Health and Human Services. George also served on active duty in the US Army as a military intelligence officer and as a paratrooper. She is a decorated Desert Storm Veteran. She holds a Bachelor of Arts in Natural Sciences from Johns Hopkins University, a Master of Science in Public Health from the University of North Carolina at Chapel Hill, and a Doctorate in Public Health from the University of Hawaii at Manoa. She is also a graduate of the Harvard University National Preparedness Leadership Initiative.

Daniel Holz (Co-Chair) is a professor at the University of Chicago in the Departments of Physics, Astronomy & Astrophysics, the Enrico Fermi Institute, and the Kavli Institute for Cosmological Physics. His research focuses on

general relativity in the context of astrophysics and cosmology. He is a member of the Laser Interferometer Gravitational-Wave Observatory (LIGO) collaboration, and was part of the team that announced the first detection of gravitational waves in early 2016 and the first multi-messenger detection of a binary neutron star in 2017. He received a 2012 National Science Foundation CAREER Award, the 2015 Quantrell Award for Excellence in Undergraduate Teaching, and the Breakthrough Prize in Fundamental Physics in 2016. Holz was selected as a Kavli Fellow of the National Academy of Sciences and is a Fellow of the American Physical Society. He received his PhD in physics from the University of Chicago and his AB in physics from Princeton University. As co-chair of the Science and Security Board, Holz is a member of the Governing Board, *ex officio*.

Sivan Kartha is a senior scientist at the Stockholm Environmental Institute whose research and publications for the past 25 years have focused on technological options and policy strategies for addressing climate change, concentrating most recently on equity and efficiency in the design of an international climate regime. He is a co-leader of SEI's Gender and Social Equity Programme, and co-director of the Climate Equity Reference Project. His current work deals primarily with the economic, political, and ethical dimensions of equitably sharing the effort of an ambitious global response to climate change. Dr. Kartha has also worked on mitigation scenarios, market mechanisms for climate actions, and the environmental and socioeconomic impacts of biomass energy. His work has enabled him to advise and collaborate with diverse organizations, including the UN Climate Convention Secretariat, various United Nations and World Bank programs, numerous government policy-making bodies and agencies, foundations, and civil society organizations throughout the developing and industrialized world. He served as a coordinating lead author in the preparation of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, released in 2014, co-leading the chapter on Equity and Sustainable Development, and has been selected as a lead author for the upcoming IPCC Sixth Assessment Report, to be released in 2021.

Biographies (cont.)

Robert Latiff retired from the US Air Force as a major general in 2006. He is an adjunct professor at the University of Notre Dame and a research professor at George Mason University's School of Engineering. He is also a member of the Intelligence Community Studies Board and the Committee on International Security and Arms Control of the National Academies of Sciences, Engineering, and Medicine. Latiff's new book, *Future Peace: Technology, Aggression, and the Rush to War*, looks at the role technology plays in leading us into conflict. He is also the author of *Future War: Preparing for the New Global Battlefield*.

Herb Lin is a senior research scholar for cyber policy and security at the Center for International Security and Cooperation, and Hank J. Holland Fellow in Cyber Policy and Security at the Hoover Institution, both at Stanford University. His research interests relate broadly to the policy and national security dimensions of cybersecurity and cyberspace, with focus on offensive operations in cyberspace and information warfare and influence operations. Lin holds additional affiliations with the National Academies, Columbia's Saltzman Institute, and the Aspen Cybersecurity Group. In 2019, he was elected a fellow of the American Association for the Advancement of Science. In 2016, he served on President Obama's Commission on Enhancing National Cybersecurity. He has previously served as a professional staff member and staff scientist for the House Armed Services Committee (1986-1990), where his portfolio included defense policy and arms control issues.

Suzet McKinney is the Principal and Director of Life Sciences for Sterling Bay where she oversees relationships with the scientific, academic, corporate, tech, and governmental sectors involved in the life sciences ecosystem. She also leads the strategy to expand Sterling Bay's footprint in life sciences nationwide. She previously served as CEO and Executive Director of the Illinois Medical District, where she managed a 24/7/365 environment that included 560 acres of medical research facilities, labs, a biotech business incubator, universities, raw land development areas, four hospitals and more than 40 healthcare related facilities. In 2020, Dr. McKinney was

appointed by Illinois Governor JB Pritzker as Operations Lead for the State of Illinois' Alternate Care Facilities, a network of alternate medical locations designed to decompress the hospital system during the COVID-19 pandemic. Dr. McKinney holds her Doctorate degree from the University of Illinois at Chicago School of Public Health and received her Bachelor of Arts in Biology from Brandeis University. She received her Master of Public Health degree and certificates in Managed Care and Health Care Administration from Benedictine University in Lisle, IL.

Steve Miller is Director of the International Security Program at the Belfer Center for Science and International Affairs in Harvard University's Kennedy School of Government. He is a Fellow of the American Academy of Arts and Sciences, where he is a member of the Committee on International Security Studies (CISS). Miller is also Co-Chair of the US Pugwash Committee, and is a member of the Council of International Pugwash. Miller co-directed the Academy's project on the Global Nuclear Future Initiative with the *Bulletin's* former Science and Security Board chair, Robert Rosner.

Raymond Pierrehumbert is Halley Professor of Physics at the University of Oxford. He was a lead author on the IPCC Third Assessment Report, and a co-author of the National Research Council report on abrupt climate change. He was awarded a John Simon Guggenheim Fellowship in 1996, which was used to launch collaborative work on the climate of Early Mars with collaborators in Paris. He is a Fellow of the American Geophysical Union (AGU), a Fellow of the American Academy of Arts and Sciences, and has been named Chevalier de l'Ordre des Palmes Académiques by the Republic of France. Pierrehumbert's central research interest is the use of fundamental physical principles to elucidate the behavior of the present and past climates of Earth and other planets, including the growing catalog of exoplanets. He leads the European Research Council Advance Grant project EXOCONDENSE.

Robert Rosner is the William E. Wrather Distinguished Service Professor in the Departments of Astronomy & Astrophysics

Biographies (cont.)

and Physics, and the Harris School of Public Policy at the University of Chicago. Rosner served as Director of Argonne National Laboratory, where he had also served as Chief Scientist. His current scientific research is mostly in the areas of laboratory and astrophysical fluid dynamics and magnetohydrodynamics, and computational physics. His policy-oriented work has focused on the future of nuclear power and the back end of the nuclear fuel cycle, as well as various aspects of electrifying the transport sector. He is a fellow of the American Physical Society, and an elected member of the American Academy of Arts & Sciences and the Norwegian Academy of Science and Letters. Rosner was chair of the Science and Security Board from 2013-2021.

Scott Sagan is the Caroline S.G. Munro Professor of Political Science, the Mimi and Peter Haas University Fellow in Undergraduate Education, Co-Director and Senior Fellow at the Center for International Security and Cooperation, and Senior Fellow at the Freeman Spogli Institute at Stanford University. He also serves as Chairman of the American Academy of Arts and Sciences' Committee on International Security Studies. Before joining the Stanford faculty, Sagan was a lecturer in the Department of Government at Harvard University and served as special assistant to the director of the Organization of the Joint Chiefs of Staff in the Pentagon. Sagan has also served as a consultant to the office of the Secretary of Defense and at the Sandia National Laboratory and the Los Alamos National Laboratory.

Robert Socolow is professor emeritus in the Department of Mechanical and Aerospace Engineering at Princeton University. From 2000 to 2019, he and Steve Pacala were the co-principal investigators of Princeton's Carbon Mitigation Initiative, a twenty-five-year (2001-2025) project supported by BP. His best-known paper, with Pacala, was in *Science* (2004): "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies." Socolow is a member of the American Academy of Arts and Sciences, an associate of the National Research Council of the National Academies, a fellow of the American Physical Society, and a fellow of the American Association for the Advancement of

Science. His awards include the 2009 Frank Kreith Energy Award from the American Society of Mechanical Engineers and the 2005 Axelson Johnson Commemorative Lecture award from the Royal Academy of Engineering Sciences of Sweden (IVA). In 2003 he received the Leo Szilard Lectureship Award from the American Physical Society.

Susan Solomon is the Lee and Geraldine Martin Professor of Environmental Studies at the Massachusetts Institute of Technology and was the Founding Director of the MIT Environmental Solutions Initiative from 2014-2015. She is well known for pioneering work that explained why there is a hole in the Antarctic ozone layer and is the author of several influential scientific papers in climate science. Solomon received the Crafoord Prize from the Swedish Academy of Sciences in 2018, the 1999 US National Medal of Science, the nation's highest scientific award, in 1999, and has also received the Grande Medaille of the French Academy of Sciences, the Blue Planet Prize in Japan, the BBVA Frontiers of Knowledge Award, and the Volvo Environment Prize. She is a member of the US National Academy of Sciences, the French Academy of Sciences, and the Royal Society in the UK. She served as co-chair for the Intergovernmental Panel on Climate Change (IPCC) fourth climate science assessment report, released in 2007. *Time* magazine named Solomon as one of the 100 most influential people in the world in 2008.

Sharon Squassoni (Co-Chair) is a research professor at the Institute for International Science and Technology Policy, Elliott School of International Affairs, at the George Washington University. She has specialized in nuclear nonproliferation, arms control and security policy for three decades, serving in the US government at the Arms Control and Disarmament Agency, the State Department, and the Congressional Research Service. Since 2007, she has directed research programs at the Center for Strategic and International Studies and the Carnegie Endowment for International Peace. A political scientist by training, she holds degrees from the State University of New York at Albany, the University of Maryland, and the National War College. As co-

Biographies (cont.)

chair of the Science and Security Board, Squassoni is a member of the Governing Board, *ex officio*.

Jon Wolfsthal is Director of the Nuclear Crisis Group, an independent project of Global Zero. Wolfsthal served previously as Special Assistant to the President of the United States for National Security Affairs and senior director at the National Security Council for arms control and nonproliferation. During his time in government, he was involved in almost every aspect of US nuclear weapons, arms control, nonproliferation and security policy. Previously, Wolfsthal was the Deputy Director of the Center for Nonproliferation Studies at the Monterey Institute of International Studies, and served for three years as special advisor to Vice President Biden on issues of nuclear security and nonproliferation. He served in several capacities during the 1990s at the US Department of Energy, including an on-the-ground assignment in North Korea during 1995-96. With Joseph Cirincione, he is the author of *Deadly Arsenals: Tracking Weapons of Mass Destruction*. Wolfsthal is a non-resident fellow with the Carnegie Endowment for International Peace.

Editor

John Mecklin is the editor-in-chief of the *Bulletin of the Atomic Scientists*. Previously, he was the top editor of *Miller-McCune* (subsequently known as *Pacific Standard*), *High Country News*, and three other magazines. Outside the publications he has led, Mecklin's writing has appeared in *Foreign Policy* magazine, the *Columbia Journalism Review*, and the Reuters news wire, among other publications. Writers working at his direction have won many major journalism contests, including the George Polk Award. Mecklin holds a master in public administration degree from Harvard's Kennedy School of Government.

Biographies (cont.)

About the *Bulletin of the Atomic Scientists*

At our core, the Bulletin of the Atomic Scientists is a media organization, publishing a free-access website and a bimonthly magazine. But we are much more. The Bulletin's website, iconic Doomsday Clock, and regular events equip the public, policy makers, and scientists with the information needed to reduce manmade threats to our existence. The Bulletin focuses on three main areas: nuclear risk, climate change, and disruptive technologies. What connects these topics is a driving belief that because humans created them, we can control them.

The Bulletin is an independent, nonprofit 501(c)(3) organization. We gather the most informed and influential voices tracking man-made threats and bring their innovative thinking to a global audience. We apply intellectual rigor to the conversation and do not shrink from alarming truths.

The Bulletin has many audiences: the general public, which will ultimately benefit or suffer from scientific breakthroughs; policymakers, whose duty is to harness those breakthroughs for good; and the scientists themselves, who produce those technological advances and thus bear a special responsibility. Our community is international, with half of our website visitors coming from outside the United States. It is also young. Half are under the age of 35.

To learn more, visit our website:

<https://thebulletin.org>

Timeline of Doomsday Clock changes

 **2021 IT IS STILL 100 SECONDS TO MIDNIGHT** If humanity is to avoid an existential catastrophe—one that would dwarf anything it has yet seen—national leaders must do a far better job of countering disinformation, heeding science, and cooperating to diminish global risks. Citizens around the world can and should organize and demand—through public protests, at ballot boxes, and in other creative ways—that their governments reorder their priorities and cooperate domestically and internationally to reduce the risk of nuclear war, climate change, and other global disasters, including pandemic disease.

 **2020 IT IS 100 SECONDS TO MIDNIGHT** Humanity continues to face two simultaneous existential dangers—nuclear war and climate change—that are compounded by a threat multiplier, cyber-enabled information warfare, that undercuts society’s ability to respond. Faced with this daunting threat landscape and a new willingness of political leaders to reject the negotiations and institutions that can protect civilization over the long term, the Science and Security Board moved the Doomsday Clock 20 seconds closer to midnight—closer to apocalypse than ever. In so doing, board members are explicitly warning leaders and citizens around the world that the international security situation is now more dangerous than it has ever been, even at the height of the Cold War.

 **2019 IT IS STILL 2 MINUTES TO MIDNIGHT** The “new abnormal” that we describe, and that the world now inhabits, is unsustainable and extremely dangerous. The world security situation can be improved, if leaders seek change and citizens demand it. It is two minutes to midnight, but there is no reason the Doomsday Clock cannot move away from catastrophe. It has done so in the past, because wise leaders acted—under pressure from informed and engaged citizens around the world. Today, citizens in every country can use the power of the Internet to fight against social media disinformation and improve the long-term prospects of their children and grandchildren. They can insist on facts, and discount nonsense. They can demand action to reduce the existential

threat of nuclear war and unchecked climate change. Given the inaction of their leaders to date, citizens of the world should make a loud and clear demand: #RewindTheDoomsdayClock.

 **2018 IT IS 2 MINUTES TO MIDNIGHT** The failure of world leaders to address the largest threats to humanity’s future is lamentable—but that failure can be reversed. It is two minutes to midnight, but the Doomsday Clock has ticked away from midnight in the past, and during the next year, the world can again move it further from apocalypse. The warning the Science and Security Board now sends is clear, the danger obvious and imminent. The opportunity to reduce the danger is equally clear. The world has seen the threat posed by the misuse of information technology and witnessed the vulnerability of democracies to disinformation. But there is a flip side to the abuse of social media. Leaders react when citizens insist they do so, and citizens around the world can use the power of the internet to improve the long-term prospects of their children and grandchildren. They can insist on facts, and discount nonsense. They can demand action to reduce the existential threat of nuclear war and unchecked climate change. They can seize the opportunity to make a safer and saner world.

 **2017 IT IS TWO AND A HALF MINUTES TO MIDNIGHT** For the last two years, the minute hand of the Doomsday Clock stayed set at three minutes before the hour, the closest it had been to midnight since the early 1980s. In its two most recent annual announcements on the Clock, the Science and Security Board warned: “The probability of global catastrophe is very high, and the actions needed to reduce the risks of disaster must be taken very soon.” In 2017, we find the danger to be even greater, the need for action more urgent. It is two and a half minutes to midnight, the Clock is ticking, global danger looms. Wise public officials should act immediately, guiding humanity away from the brink. If they do not, wise citizens must step forward and lead the way.

Timeline (cont.)

 **2016 IT IS STILL 3 MINUTES TO MIDNIGHT** “Last year, the Science and Security Board moved the Doomsday Clock forward to three minutes to midnight, noting: ‘The probability of global catastrophe is very high, and the actions needed to reduce the risks of disaster must be taken very soon.’ That probability has not been reduced. The Clock ticks. Global danger looms. Wise leaders should act—immediately.”

 **2015 IT IS 3 MINUTES TO MIDNIGHT** “Unchecked climate change, global nuclear weapons modernizations, and outsized nuclear weapons arsenals pose extraordinary and undeniable threats to the continued existence of humanity, and world leaders have failed to act with the speed or on the scale required to protect citizens from potential catastrophe. These failures of political leadership endanger every person on Earth.” Despite some modestly positive developments in the climate change arena, current efforts are entirely insufficient to prevent a catastrophic warming of Earth. Meanwhile, the United States and Russia have embarked on massive programs to modernize their nuclear triads—thereby undermining existing nuclear weapons treaties. “The clock ticks now at just three minutes to midnight because international leaders are failing to perform their most important duty—ensuring and preserving the health and vitality of human civilization.”

 **2012 IT IS 5 MINUTES TO MIDNIGHT** “The challenges to rid the world of nuclear weapons, harness nuclear power, and meet the nearly inexorable climate disruptions from global warming are complex and interconnected. In the face of such complex problems, it is difficult to see where the capacity lies to address these challenges.” Political processes seem wholly inadequate; the potential for nuclear weapons use in regional conflicts in the Middle East, Northeast Asia, and South Asia are alarming; safer nuclear reactor designs need to be developed and built, and more stringent oversight, training, and attention are needed to prevent future disasters; the pace of technological solutions to address climate change may not be adequate to meet the hardships that large-scale disruption of the climate portends.

 **2010 IT IS 6 MINUTES TO MIDNIGHT** International cooperation rules the day. Talks between Washington and Moscow for a follow-on agreement to the Strategic Arms Reduction Treaty are nearly complete, and more negotiations for further reductions in the U.S. and Russian nuclear arsenal are already planned. Additionally, Barack Obama becomes the first U.S. president to publicly call for a nuclear-weapon-free world. The dangers posed by climate change are still great, but there are pockets of progress. Most notably: At Copenhagen, the developing and industrialized countries agree to take responsibility for carbon emissions and to limit global temperature rise to 2 degrees Celsius.

 **2007 IT IS 5 MINUTES TO MIDNIGHT** The world stands at the brink of a second nuclear age. The United States and Russia remain ready to stage a nuclear attack within minutes, North Korea conducts a nuclear test, and many in the international community worry that Iran plans to acquire the Bomb. Climate change also presents a dire challenge to humanity. Damage to ecosystems is already taking place; flooding, destructive storms, increased drought, and polar ice melt are causing loss of life and property.

 **2002 IT IS 7 MINUTES TO MIDNIGHT** Concerns regarding a nuclear terrorist attack underscore the enormous amount of unsecured—and sometimes unaccounted for—weapon-grade nuclear materials located throughout the world. Meanwhile, the United States expresses a desire to design new nuclear weapons, with an emphasis on those able to destroy hardened and deeply buried targets. It also rejects a series of arms control treaties and announces it will withdraw from the Anti-Ballistic Missile Treaty.

 **1998 IT IS 9 MINUTES TO MIDNIGHT** India and Pakistan stage nuclear weapons tests only three weeks apart. “The tests are a symptom of the failure of the international community to fully commit itself to control the spread of nuclear weapons—and to work toward substantial reductions in the numbers of these weapons,” a dismayed *Bulletin* reports. Russia and the United States continue to serve as poor

Timeline (cont.)

examples to the rest of the world. Together, they still maintain 7,000 warheads ready to fire at each other within 15 minutes.

 **1995 IT IS 14 MINUTES TO MIDNIGHT**
Hopes for a large post-Cold War peace dividend and a renouncing of nuclear weapons fade. Particularly in the United States, hard-liners seem reluctant to soften their rhetoric or actions, as they claim that a resurgent Russia could provide as much of a threat as the Soviet Union. Such talk slows the rollback in global nuclear forces; more than 40,000 nuclear weapons remain worldwide. There is also concern that terrorists could exploit poorly secured nuclear facilities in the former Soviet Union.

 **1991 IT IS 17 MINUTES TO MIDNIGHT**
With the Cold War officially over, the United States and Russia begin making deep cuts to their nuclear arsenals. The Strategic Arms Reduction Treaty greatly reduces the number of strategic nuclear weapons deployed by the two former adversaries. Better still, a series of unilateral initiatives remove most of the intercontinental ballistic missiles and bombers in both countries from hair-trigger alert. “The illusion that tens of thousands of nuclear weapons are a guarantor of national security has been stripped away,” the *Bulletin* declares.

 **1990 IT IS 10 MINUTES TO MIDNIGHT**
As one Eastern European country after another (Poland, Czechoslovakia, Hungary, Romania) frees itself from Soviet control, Soviet General Secretary Mikhail Gorbachev refuses to intervene, halting the ideological battle for Europe and significantly diminishing the risk of all-out nuclear war. In late 1989, the Berlin Wall falls, symbolically ending the Cold War. “Forty- four years after Winston Churchill’s ‘Iron Curtain’ speech, the myth of monolithic communism has been shattered for all to see,” the *Bulletin* proclaims.

 **1988 IT IS 6 MINUTES TO MIDNIGHT**
The United States and Soviet Union sign the historic Intermediate-Range Nuclear Forces Treaty, the first agreement to actually ban a whole category of nuclear weapons. The

leadership shown by President Ronald Reagan and Soviet Premier Mikhail Gorbachev makes the treaty a reality, but public opposition to U.S. nuclear weapons in Western Europe inspires it. For years, such intermediate-range missiles had kept Western Europe in the crosshairs of the two superpowers.

 **1984 IT IS 3 MINUTES TO MIDNIGHT**
U.S.-Soviet relations reach their iciest point in decades. Dialogue between the two superpowers virtually stops. “Every channel of communications has been constricted or shut down; every form of contact has been attenuated or cut off. And arms control negotiations have been reduced to a species of propaganda,” a concerned *Bulletin* informs readers. The United States seems to flout the few arms control agreements in place by seeking an expansive, space-based anti-ballistic missile capability, raising worries that a new arms race will begin.

 **1981 IT IS 4 MINUTES TO MIDNIGHT**
The Soviet invasion of Afghanistan hardens the U.S. nuclear posture. Before he leaves office, President Jimmy Carter pulls the United States from the Olympic Games in Moscow and considers ways in which the United States could win a nuclear war. The rhetoric only intensifies with the election of Ronald Reagan as president. Reagan scraps any talk of arms control and proposes that the best way to end the Cold War is for the United States to win it.

 **1980 IT IS 7 MINUTES TO MIDNIGHT**
Thirty-five years after the start of the nuclear age and after some promising disarmament gains, the United States and the Soviet Union still view nuclear weapons as an integral component of their national security. This stalled progress discourages the *Bulletin*: “[The Soviet Union and United States have] been behaving like what may best be described as ‘nucleoholics’—drunks who continue to insist that the drink being consumed is positively ‘the last one,’ but who can always find a good excuse for ‘just one more round.’”

Timeline (cont.)

 **1974 IT IS 9 MINUTES TO MIDNIGHT**
South Asia gets the Bomb, as India tests its first nuclear device. And any gains in previous arms control agreements seem like a mirage. The United States and Soviet Union appear to be modernizing their nuclear forces, not reducing them. Thanks to the deployment of multiple independently targetable reentry vehicles (MIRV), both countries can now load their intercontinental ballistic missiles with more nuclear warheads than before.

 **1972 IT IS 12 MINUTES TO MIDNIGHT**
The United States and Soviet Union attempt to curb the race for nuclear superiority by signing the Strategic Arms Limitation Treaty (SALT) and the Anti-Ballistic Missile (ABM) Treaty. The two treaties force a nuclear parity of sorts. SALT limits the number of ballistic missile launchers either country can possess, and the ABM Treaty stops an arms race in defensive weaponry from developing.

 **1969 IT IS 10 MINUTES TO MIDNIGHT**
Nearly all of the world's nations come together to sign the Nuclear Non-Proliferation Treaty. The deal is simple—the nuclear weapon states vow to help the treaty's non-nuclear weapon signatories develop nuclear power if they promise to forego producing nuclear weapons. The nuclear weapon states also pledge to abolish their own arsenals when political conditions allow for it. Although Israel, India, and Pakistan refuse to sign the treaty, the *Bulletin* is cautiously optimistic: “The great powers have made the first step. They must proceed without delay to the next one—the dismantling, gradually, of their own oversized military establishments.”

 **1968 IT IS 7 MINUTES TO MIDNIGHT**
Regional wars rage. U.S. involvement in Vietnam intensifies, India and Pakistan battle in 1965, and Israel and its Arab neighbors renew hostilities in 1967. Worse yet, France and China develop nuclear weapons to assert themselves as global players. “There is little reason to feel sanguine about the future of our society on the world scale,” the *Bulletin* laments. “There is a mass revulsion against war, yes; but no sign of conscious intellectual leadership in a rebellion

against the deadly heritage of international anarchy.”

 **1963 IT IS 12 MINUTES TO MIDNIGHT**
After a decade of almost non-stop nuclear tests, the United States and Soviet Union sign the Partial Test Ban Treaty, which ends all atmospheric nuclear testing. While it does not outlaw underground testing, the treaty represents progress in at least slowing the arms race. It also signals awareness among the Soviets and United States that they need to work together to prevent nuclear annihilation.

 **1960 IT IS 7 MINUTES TO MIDNIGHT**
Political actions belie the tough talk of “massive retaliation.” For the first time, the United States and Soviet Union appear eager to avoid direct confrontation in regional conflicts such as the 1956 Egyptian-Israeli dispute. Joint projects that build trust and constructive dialogue between third parties also quell diplomatic hostilities. Scientists initiate many of these measures, helping establish the International Geophysical Year, a series of coordinated, worldwide scientific observations, and the Pugwash Conferences, which allow Soviet and American scientists to interact.

 **1953 IT IS 2 MINUTES TO MIDNIGHT**
After much debate, the United States decides to pursue the hydrogen bomb, a weapon far more powerful than any atomic bomb. In October 1952, the United States tests its first thermonuclear device, obliterating a Pacific Ocean islet in the process; nine months later, the Soviets test an H-bomb of their own. “The hands of the Clock of Doom have moved again,” the *Bulletin* announces. “Only a few more swings of the pendulum, and, from Moscow to Chicago, atomic explosions will strike midnight for Western civilization.”

 **1949 IT IS 3 MINUTES TO MIDNIGHT**
The Soviet Union denies it, but in the fall, President Harry Truman tells the American public that the Soviets tested their first nuclear device, officially starting the arms race. “We do not advise Americans that doomsday is near and that they can expect atomic bombs to start falling on

Timeline (cont.)

their heads a month or year from now,” the *Bulletin* explains. “But we think they have reason to be deeply alarmed and to be prepared for grave decisions.”

 **1947 IT IS 7 MINUTES TO MIDNIGHT** As the *Bulletin* evolves from a newsletter into a magazine, the Clock appears on the cover for the first time. It symbolizes the urgency of the nuclear dangers that the magazine’s founders—and the broader scientific community—are trying to convey to the public and political leaders around the world.