

**Bulletin  
of the  
Atomic  
Scientists**

**A time of unprecedented danger:  
It is 90 seconds to midnight**

2023 Doomsday Clock Statement

Science and Security Board

Bulletin of the Atomic Scientists

Editor, John Mecklin

**IT IS 90 SECONDS  
TO MIDNIGHT**



*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 10 Nobel laureates. The Clock has become a universally recognized indicator of the world's vulnerability to global catastrophe caused by manmade technologies.*

## **A time of unprecedented danger: It is 90 seconds to midnight**

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**T**his year, the Science and Security Board of the Bulletin of the Atomic Scientists moves the hands of the Doomsday Clock forward, largely (though not exclusively) because of the mounting dangers of the war in Ukraine. The Clock now stands at 90 seconds to midnight—the closest to global catastrophe it has ever been.

The war in Ukraine may enter a second horrifying year, with both sides convinced they can win. Ukraine's sovereignty and broader European security arrangements that have largely held since the end of World War II are at stake. Also, Russia's war on Ukraine has raised profound questions about how states interact, eroding norms of international conduct that underpin successful responses to a variety of global risks.

And worst of all, Russia's thinly veiled threats to use nuclear weapons remind the world that escalation of the conflict—by accident, intention, or miscalculation—is a terrible risk. The possibility that the conflict could spin out of anyone's control remains high.

Russia's recent actions contravene decades of commitments by Moscow. In 1994, Russia joined the United States and United Kingdom in Budapest, Hungary, to solemnly declare that it would “respect the independence and sovereignty and the existing borders of Ukraine” and “refrain from the threat or use of force against the territorial integrity or political independence of Ukraine...” These assurances were made explicitly on the understanding that Ukraine would relinquish nuclear weapons on its soil and sign the Nuclear Non-Proliferation Treaty—both of which Ukraine did.

Russia has also brought its war to the Chernobyl and Zaporizhzhia nuclear reactor sites, violating international protocols and risking widespread release of radioactive materials. Efforts by the International Atomic Energy Agency to secure these plants so far have been rebuffed.

As Russia's war on Ukraine continues, the last remaining nuclear weapons treaty between Russia and the United States, New START,

stands in jeopardy. Unless the two parties resume negotiations and find a basis for further reductions, the treaty will expire in February 2026. This would eliminate mutual inspections, deepen mistrust, spur a nuclear arms race, and heighten the possibility of a nuclear exchange.

As UN Secretary-General Antonio Guterres warned in August, the world has entered “a time of nuclear danger not seen since the height of the Cold War.”

The war’s effects are not limited to an increase in nuclear danger; they also undermine global efforts to combat climate change. Countries dependent on Russian oil and gas have sought to diversify their supplies and suppliers, leading to expanded investment in natural gas exactly when such investment should have been shrinking.


In the context of a hot war and against the backdrop of nuclear threats, Russia’s false accusations that Ukraine planned to use radiological dispersal devices, chemical weapons, and biological weapons take on new meaning as well. The continuing stream of disinformation about bioweapons laboratories in Ukraine raises concerns that Russia itself may be thinking of deploying such weapons, which many experts believe it continues to develop.

Russia’s invasion of Ukraine has increased the risk of nuclear weapons use, raised the specter of biological and chemical weapons use, hamstrung the world’s response to climate change, and hampered international efforts to

deal with other global concerns. The invasion and annexation of Ukrainian territory have also violated international norms in ways that may embolden others to take actions that challenge previous understandings and threaten stability.

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There is no clear pathway for forging a just peace that discourages future aggression under the shadow of nuclear weapons. But at a minimum, the United States must keep the door open to principled engagement with Moscow that reduces the dangerous increase in nuclear risk the war has fostered. One element of risk reduction could involve sustained, high-level US military-

to-military contacts with Russia to reduce the likelihood of miscalculation. The US government, its NATO allies, and Ukraine have a multitude of channels for dialogue; they all should be explored. Finding a path to serious peace negotiations could go a long way toward reducing the risk of escalation. In this time of unprecedented global danger, concerted action is required, and every second counts. 

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*Additional information on the threats posed by nuclear weapons, climate change, biological events, and the misuse of other disruptive technologies follows below.*

## **An exceedingly dangerous nuclear situation**

Thinly veiled Russian threats to use nuclear weapons in the Ukraine war constitute the worst nuclear development in 2022. Warnings and cautionary statements have silenced such threats for now, but Russian officials should categorically renounce threats to use weapons of mass destruction in Ukraine.

Beyond the Ukraine conflict, previous trends of expansion and modernization of nuclear arsenals continue, with little progress to show in negotiations with either North Korea or Iran over their nuclear programs. US and Russian nuclear forces are still constrained by New START, but there is no certainty the treaty will be extended beyond 2026.

China's considerable expansion of its nuclear capabilities is particularly troubling, given its consistent refusal to consider measures to enhance transparency and predictability. The US Defense Department claims Beijing may increase its arsenal fivefold by 2035 and could soon rival the nuclear capabilities of the United States and Russia, with unpredictable consequences for stability.

North Korea has greatly stepped up its intermediate- and longer-range missile testing. In late March, North Korea successfully launched an intercontinental ballistic missile for the first time since 2017. In the following months, it also launched numerous other ballistic missiles, most with short ranges.

Perhaps most concerning, on October 4, North Korea launched an intermediate-range ballistic missile over Japan. Meanwhile, US officials contend that North Korea is preparing to conduct its seventh nuclear weapon test.

Iran continues to increase its uranium enrichment capacity, albeit under international safeguards outside the confines of the Joint Comprehensive Plan of Action that once restrained it. This positions Iran closer to a nuclear weapons capability, should it decide to cross that threshold. Returning to the nuclear deal would reduce risks and provide

a path forward, and the United States, Europe, and other countries have made reasonable efforts to revive the deal. But instability in Iran and Tehran's support for Russia's war against Ukraine will complicate successful negotiations to keep Iran from acquiring nuclear weapons.

India continues to modernize its nuclear arsenal of some 160 warheads, with new

delivery systems now under development to complement or replace existing nuclear-capable aircraft, land-based delivery systems, and sea-based systems. Pakistan has an arsenal of similar size and continues to expand its warheads, delivery systems, and fissile material production.

The United States, Russia, and China are now pursuing full-fledged nuclear weapons modernization programs, setting the table for a dangerous new "third nuclear age" of competition. Long-standing concerns about

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arms racing in South Asia and missile arms races in Northeast Asia complete a dismal picture that needs to be addressed.

As a matter of priority, all five permanent members of the UN Security Council—including, especially, Russia—should make a renewed commitment to confront nuclear dangers through arms control efforts and strategic stability agreements. At the proper time, major multilateral nuclear diplomacy will be needed precisely because of a dire reality the Ukraine crisis underscores: The existential threat posed by nuclear weapons endures even as political circumstances change.

### **Countervailing dynamics: Addressing climate change during the invasion of Ukraine**

Addressing climate change requires faith in institutions of multilateral governance. The geopolitical fissure opened by the invasion of Ukraine has weakened the global will to cooperate while undermining confidence in the durability, or even the feasibility, of broad-based multilateral collaboration.

With Russia second only to the United States in global production of both natural gas and oil, the invasion of Ukraine sparked a rush to establish independence from Russian energy supplies, particularly in the European Union. From the standpoint of climate change, this has contributed to two countervailing dynamics.

First, the elevated energy prices have spurred investment in renewables and motivated countries to implement policies that support renewables development. With this rise in deployment, the International Energy Agency now projects that wind and solar

energy combined will approach 20 percent of global power generation five years from now, with China installing nearly half of the new renewable power capacity.

At the same time, however, high natural gas prices have driven a quest to develop new gas supplies, spurring investment in natural gas production and export infrastructure in the United States, the EU, Africa, and elsewhere, largely financed by major oil and gas transnationals and investment firms. This private capital continues to flow into developing new fossil fuel resources, even while public finance is facing pressure to pull out. All G7 countries have pledged to end public financing of international fossil fuel projects this year, and the Beyond Oil and Gas Alliance, a group of eight countries, has formally committed to end new concessions, licensing or leasing rounds for oil and gas production and exploration, and to set a timeline for ending production that is consistent with their Paris agreement pledges.

Notwithstanding these two processes, both of which should in principle reduce demand for Russian gas, Russia was on course in 2022 to earn as much as the previous year from oil and gas exports, largely owing to continued European demand.

As a consequence, global carbon dioxide emissions from burning fossil fuels, after having rebounded from the COVID economic decline to an all-time high in 2021, continued to rise in 2022 and hit another record high. A decline in Chinese emissions was overshadowed by a rise in the United States, India, and elsewhere.

The rise in emissions in 2022 accelerated the ongoing increase in the concentration of greenhouse gases in the atmosphere, which



will continue so long as emissions of carbon dioxide continue. Not only did weather extremes continue to plague diverse parts of the globe, but they were more evidently attributable to climate change. Countries of West Africa experienced floods that were among the most lethal in their histories, owing to a rainfall event that was assessed to be 80 times more likely because of climate change. Extreme temperatures in Central Europe, North America, China, and other regions of the Northern Hemisphere this past summer led to water shortages and soil drought conditions that led in turn to poor harvests, further undermining food security at a time when the Ukraine conflict has already driven food price increases. It is Pakistan, however, that faced the year's most dramatic manifestation of Earth's increasingly volatile climate: intense floods due to a "monsoon on steroids" that inundated one-third of the country. The flooding was described as the worst in the country's history, affecting 33 million people directly and unleashing cascading effects, including a major crop failure, an epidemic of waterborne diseases, and the destruction of infrastructure, homes, livestock, and livelihoods.

Against the backdrop of this year's climate-related tragedies, the UN climate regime took a promising step forward on the adaptation front at its annual negotiations in Sharm el Sheikh, Egypt. The parties at the UN climate conference reached a compromise agreement to create a fund to support poor and vulnerable countries in addressing the mounting toll from climate change impacts. To reach the intended goal, the cooperation that led to this agreement needs to persist in this coming year's negotiations, when countries take up the question of actually contributing money to the fund.

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Countries were unable, however, to adopt a formal decision to agree to phase out fossil fuels, and even more disappointing, they did essentially nothing to assure that previous commitments to reach net zero greenhouse gas emissions would be fulfilled.

### **A daunting array of biological threats**

The existing biological threat landscape makes clear that the international community needs to improve its ability to prevent disease outbreaks, to detect them quickly when they occur, and to respond effectively to limit their scope.

Devastating events like the COVID-19 pandemic can no longer be considered rare, once-a-century occurrences. The total number and diversity of infectious disease outbreaks has increased significantly since 1980, with more than half caused by zoonotic diseases (that is, disease originating in animals and transmitted to humans). As such, zoonoses put the human population at significant risk for pandemics. There is immense, uncharacterized diversity within the 26 virus families and the

many phyla of bacteria and other microbes known to infect humans. The world's ability to predict which of these viruses and microbes are most likely to cause human disease is woefully inadequate.

Laboratory accidents continue to occur frequently. Opportunities for human error, limited understanding of novel disease characteristics, lack of local government knowledge about the types of research occurring in labs in their jurisdictions, and confusion about lab safety requirements all challenge current laboratory biosafety and biosecurity programs. It is also easier now than ever to obtain and modify pathogens, increasing the chances of pandemics caused by laboratory accidents.

We live in a time of revolutionary advances in the life sciences and associated technologies. Researchers can engineer living things to acquire new traits with increasing ease and reliability, especially viruses that can be synthesized de novo in the laboratory. But oversight regimes, strategies for risk assessment and risk mitigation, and the establishment of agreed-upon norms for scientific pursuit lag further and further behind, as biological science and technology advance faster and faster. Biological information is increasingly a double-edged sword: It empowers anyone with requisite capabilities to work with and produce dangerous pathogens, even as it enables remarkable advances for good in biology-based sciences and

technology. Leaders around the world must confront the possibility of global catastrophic biological risks—biological events that could lead to sudden, extraordinary, widespread disasters—that test or exceed the collective capability of national and international governments and the private sector to control.

In its 2022 report, *Adherence to and Compliance with Arms Control, Nonproliferation, and Disarmament Agreements and Commitments*, the US State Department assessed that: Russia maintains an offensive biological weapons program; North Korea has produced biological agents and maintains a program to weaponize them for use in warfare; Iran has not abandoned its intent to conduct

research and development of biological agents for offensive uses; and China has engaged in dual-use activities that may be in violation of the *Biological Weapons Convention*.

Recent events—including especially the Russian invasion of Ukraine and Russia's continuing disinformation efforts in regard to biological weapons—have changed the landscape of biological threats. The risk that Russia will engage in biological warfare

increases as conditions in Ukraine become more chaotic, weakening norms of warfare. Escalation of the war in Ukraine poses many potentially existential threats to humanity; one of them is biological.

No matter the potential source—natural, accidental, or intentional—there are

**Escalation of the war in Ukraine poses many potentially existential threats to humanity; one of them is biological.**

steps national leaders can take to reduce catastrophic biological risks. Every country must make greater investments in public health. Every country should eliminate biological weapons and dismantle programs producing them. And all countries can vastly improve the world's ability to identify outbreaks before they become epidemics and pandemics if they invest in disease surveillance systems; share data, analytics, and intelligence on biological events; and develop the ability to identify and attribute biological events quickly.

Pathogens are not stopped by national borders. Debilitating illness, widespread death, and disease-induced disaster can be avoided if countries around the world cooperate on global health strategies and make investments in science, technology, research, and development in the biosecurity sector.

### **Disruptive technologies: A varied threat environment**

Developments regarding potential threats from disruptive technologies told a mixed story last year.

On the disinformation front, there was some good news: For the most part, the American electorate rejected election deniers in 2022, and in France, President Emmanuel Macron overcame a historic challenge from his country's far-right candidate Marine Le Pen. Meanwhile, the Biden administration continued its efforts to increase the role of scientists in informing public policy.

On the other hand, cyber-enabled disinformation continues unabated. In the United States, political opposition to a "Disinformation Governance Board" proposed by the Department of Homeland Security was

grounded in willful misrepresentation and the politics of personal destruction. But non-substantive and misleading as its messages were, the opposition succeeded in causing the department to withdraw its proposal. These types of attacks are hardly new but are emblematic of corruption in the information environment.

**Beyond his threats to use nuclear weapons, Russian President Vladimir Putin has also shredded norms of behavior in space.**

Inside Russia, meanwhile, government control of the information ecosystem has blocked the wide dissemination of truthful information about the Ukraine war. Chinese use of surveillance technology has continued apace in Xinjiang. As we stated last year, the extensive use of surveillance technologies has disturbing implications for human rights and poses a distinct threat to civil society.

As for cyber conflict, again the story is a mix of bad and good news. The world continues to suffer from widespread cyberattacks. But—many predictions to the contrary—Russian cyberattacks against the United States and European Union in retaliation for sanctions related to the invasion of Ukraine either did not happen or were unsuccessful. Moreover, Russian cyberattacks on Ukraine proved ineffective as a coercive tool.



Technology-enabled open-source intelligence has had a profound impact on the war in Ukraine, providing imagery that documents Russian war crimes and provides valuable situational awareness for Ukrainian forces. Commercial imagery from space was widely shared, chronicling the Russian buildup to the invasion and giving Ukrainian military decision makers additional input. The SpaceX Starlink system has succeeded both in maintaining internet service across Ukraine and in responding quickly and effectively to Russian cyberattacks.

Starlink has also demonstrated the potential resilience of large constellations of small satellites in low Earth orbit. This approach could be applied to other space missions, such as navigation and early warning. Such satellite constellations would be highly resistant to anti-satellite attack and should therefore contribute to stability. The US Defense Department now appears poised to move toward this approach under the Space Development Agency's National Defense Space Architecture. In addition, the United States has pledged unilaterally to refrain from kinetically destructive, direct-ascent anti-satellite weapons tests and invited other nations to join that moratorium.

Beyond his threats to use nuclear weapons, Russian President Vladimir Putin has also shredded norms of behavior in space, publicly threatening to use an anti-satellite weapon against US Starlink satellites, arguing that they are not merely a commercial system but a military one as well. Ukraine has made use of Starlink in its conflict with Russia.

US space plans anticipate the deployment of a variety of satellite-based sensors to track missile launchers and other mobile targets, thereby enabling preemptive attacks. Although

intended to counter North Korea, these sensor arrays will undoubtedly cause concern in Russia and China and thus potentially threaten strategic stability.

Both Russia and China engaged in worrisome space activity in 2022, with Russia once again launching an "inspector" satellite that reportedly tailed a high-value US government satellite in its orbit.

Finally, the war in Ukraine has demonstrated the value of high-tech weapons against conventional platforms such as airplanes and tanks. Armed drones and precision-guided munitions have been important assets to both sides. Although these technologies are not new, their disruptive potential against traditional ground forces has been demonstrated once again. 

# Science and Security Board Biographies

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**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

## Biographies (cont.)

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he led the environment and energy and the national security and international 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.

**Alexander Glaser** is an associate professor in the School of Public and International Affairs and in the Department of Mechanical and Aerospace Engineering. Glaser has been co-directing Princeton's Program on Science and Global Security since 2016. Along with Harold Feiveson, Zia Mian, and Frank von Hippel, he is co-author of *Unmaking the Bomb* (MIT Press, 2014). For Princeton's work on nuclear warhead verification, *Foreign Policy* magazine selected him as one of the 100 Leading Global Thinkers of 2014. In September 2020, Glaser was elected a Fellow of the American Physical Society for "advancing the scientific and technical basis for nuclear arms control, nonproliferation, and disarmament verification." Along with Tamara Patton and Susanna Pollack, he is one of the executive producers of the VR documentary *On the Morning You Wake*. Glaser holds a PhD in Physics from Darmstadt University, Germany.

**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*.

## Biographies (cont.)

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**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.

**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.



## Biographies (cont.)

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**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.

**David A. Relman** is the Thomas C. and Joan M. Merigan Professor in Medicine, Professor of Microbiology & Immunology, and Senior Fellow at the Center for International Security and Cooperation at Stanford University. Relman was an early pioneer in the modern study of the human indigenous microbiota (microbiome). His current research work focuses on assembly, diversity, stability, and resilience of human microbial communities. He served as President of the Infectious Diseases Society of America. Among policy-relevant activities in biological security and emerging infections, Relman was a founding member of the National Science Ad-

visory Board on Biosecurity, and currently serves on the Intelligence Community Studies Board at the U.S. National Academies of Science, Engineering, and Medicine, and on the Defense Science Board at the U.S. Department of Defense. He is a member of the National Academy of Medicine and the American Academy of Arts and Sciences.

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



## Biographies (cont.)

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**Ambuj Sagar** is the deputy director (strategy & planning) and the Vipula and Mahesh Chaturvedi Professor of Policy Studies at the Indian Institute of Technology (IIT) Delhi. He previously served as the founding head of the School of Public Policy at IIT Delhi. Sagar was a lead author in Working Group III of the IPCC's Sixth Assessment Report and currently is a member of the Independent Group of Scientists appointed by the UN Secretary-General to prepare the Global Sustainable Development Report 2023. He has served as a respected advisor to various Indian government agencies as well as many multilateral and bilateral agencies and was a member of the NAS panel that authored the recent report on geoengineering research and governance.

**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-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

## Biographies (cont.)

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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.

# About the *Bulletin of the Atomic Scientists*

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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, policymakers, 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, including developments in biotechnology. 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 the Doomsday Clock

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## IT IS STILL 100 SECONDS TO MIDNIGHT

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.



## 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.



## 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—a warning to 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.



## IT IS STILL 2 MINUTES TO MIDNIGHT

The “new abnormal” that the world now inhabits is unsustainable and extremely dangerous. 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 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.



## 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. 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 seize the opportunity to make a safer and saner world.



## 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. 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.



## 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.”



## 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.” 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.”

# Timeline (cont.)

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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 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.



# Timeline (cont.)

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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.'"



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.

# Timeline (cont.)

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## 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.



## 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.”



## 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 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.”



## 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.