

# es 90 Seconds



# **Bulletin of the Atomic Scientists**

## **2022 Annual Report**

### **It is 90 seconds to midnight**

#### **The Mission**

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 man-made 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.

<b>01</b>	<b>From the Board of Sponsors Chair</b>
<b>02</b>	<b>From the President &amp; CEO</b>
<b>03</b>	<b>Amnesia Atómica NYC</b>
<b>06</b>	<b>From the Editor-in-Chief</b>
<b>07</b>	<b>@thebulletin</b>
<b>10</b>	<b>Monitoring and managing biorisks</b>
<b>12</b>	<b>The Magazine</b>
<b>13</b>	<b>Welcoming new staff</b>
<b>14</b>	<b>Rieser Award and essay</b>
<b>17</b>	<b>Clock Announcement</b>
<b>20</b>	<b>2023 Clock Statement</b>
<b>26</b>	<b>Board of Sponsors</b>
<b>27</b>	<b>Science and Security Board</b>
<b>28</b>	<b>Governing Board</b>
<b>29</b>	<b>Editorial Fellows/Stanford undergraduates</b>
<b>30</b>	<b>Human/Nature</b>
<b>31</b>	<b>Arts/Science initiative</b>
<b>32</b>	<b>Conversations Before Midnight</b>
<b>33</b>	<b>In memoriam</b>
<b>34</b>	<b>Philanthropy</b>
<b>35</b>	<b>Donor recognition</b>
<b>39</b>	<b>Financials</b>
<b>40</b>	<b>Leadership and staff</b>

# From the Board of Sponsors Chair

## Siegfried S. Hecker



**“Let’s get down to the serious and hopeful business of giving the world more time to thrive.”**

**With the Doomsday Clock set at 90 seconds to midnight, the world is challenged as never before.**

Scientists are likewise challenged to meet the moment—to find every way possible to engage with policymakers and citizens to move us away from the precipice—to turn back the hands of the Clock to a less risky setting.

I am honored to begin my term as Chair of the Bulletin’s Board of Sponsors. The Bulletin is uniquely positioned to articulate why and how we can do more to prevent the use of nuclear weapons, restore environmental sustainability, and discover ways to use advanced technology for humanity’s benefit.

It is a true privilege to succeed as Chair my colleague and friend, Bill Perry, the 19th US Secretary of Defense, whose conviction that we must describe Doomsday in order to prevent it, succinctly summarizes the Bulletin’s mission. Among his many accomplishments, Bill presided over the dismantlement of more than 8,000 nuclear weapons in the former Soviet states—a feat for which we all owe him an enormous debt of gratitude. At Stanford University, he taught several thousand students the importance of the intersection of technology and policy. Bulletin leaders, including Bill, fellow Sponsors, and Executive Chair and former Governor of the State of California Jerry Brown, share a sense of urgency that we dare not ignore.

As scientists and policymakers, we are oriented toward finding solutions as the challenges mount. Greenhouse gases are warming the atmosphere and triggering climate disasters, the COVID-19 pandemic has opened our eyes further to the potential for biothreats, and disinformation undermines our capacity to grapple openly with the facts.

As a nuclear security specialist, I have been a regular contributor to the Bulletin for years, and with my colleagues at Los Alamos and in academe, rely on its record of lessons learned from the creation of atomic weapons, through the Cold War and various nuclear arms regimes, up to the current unstable state of affairs. With Russia recklessly threatening to use nuclear weapons in Ukraine, North Korea testing increasingly menacing missiles, and

China emerging as a great nuclear-armed power, the fabric of the nuclear order is devastatingly frayed.

When the Bulletin pushes its Clock 10 seconds closer to a metaphoric Doomsday, the world rightfully expects to know why—and options to contain the risk. The Board of Sponsors will find more ways to stay involved and support the organization in new ways appropriate to the current moment. Last year, Governor Brown called on citizens to avert catastrophe “by recognizing the stark vulnerability that the people of the world share.” Our correction window just got 10 seconds shorter.

This is not a time for panic, but it is a time to set aside differences and sideshows. Let’s get down to the serious and hopeful business of giving the world more time to thrive.

Siegfried S. Hecker

# From the President & CEO

Rachel Bronson



**“We are growing because there is an urgent demand for what we do.”**

## **The year 2022 was dominated by Russia's invasion of Ukraine.**

Russian President Vladimir Putin recklessly issued nuclear threats, leading US President Joe Biden to conclude that the risk of nuclear use is at the highest level since the 1962 Cuban Missile Crisis. United Nations Secretary General António Guterres similarly stated that we are facing “a time of nuclear danger not seen since the height of the Cold War.”

The Bulletin has long warned of growing nuclear dangers—documenting them as they unfolded, providing a platform on which leading experts dispelled misinformation, and offering policy recommendations for moving forward.

In the days before the invasion, our then-social media coordinator Sarah Starkey published a YouTube video drawing early attention to President Putin's reckless nuclear rhetoric. That video drew over 5 million views across multiple social media platforms. On the day after the Russian invasion of Ukraine, Bulletin editor Matt Field published an article on the risks of dangerous pathogens being released, an article that nearly half a million people read.

In the five weeks following the invasion of Ukraine, two million people visited the Bulletin's website, many coming to read the Science and Security Board's statement condemning Russia's invasion. The Bulletin served an invaluable role providing audiences with the information they needed to understand dramatic events as they unfolded.

But there's something else we know. Even if we find a way out of the current situation in Ukraine, and reduce the nuclear threat, the climate will continue to change, artificial intelligence will continue to evolve, mis- and disinformation will continue to swirl, and biorisks will continue to multiply. The Bulletin's mandate, to provide the public, scientists, and policymakers with the information to reduce man-made threats to our existence, demands ongoing vigilance.

In the bio space, the Bulletin launched a major new taskforce in 2022 focused on “Creating the Framework for Tomorrow's Pathogen Research.” Members include more than 20 globally recognized experts in

virology, law, ethics, and epidemiology. We also partnered with leading experts Filippa Lentzos (King's College London), and Greg Koblenz (George Mason University) in a new project mapping Biosafety Labs 3+ and 4 (BSL 3+ and BSL4). The project was launched at King's College London in December. Multimedia editor Erik English has served as the Bulletin's lead on this project.

Throughout the year, the Bulletin's biorisk coverage received extraordinary attention. The United Nations' Office for Disarmament Affairs included 14 Bulletin articles as recommended reading in advance of the Ninth Review Conference of the Bioweapons Convention, more than any other think tank, government agency, or publication.

In response to fast-changing events, the Bulletin team works around the clock producing first-class analysis, supported by our Science and Security Board members, Sponsors, and Executive Chair Jerry Brown. We are increasing our capacity, experimenting with new features, and adding new social media platforms. We are motivated by, and responsible to, our fast-growing community that encompassed 6.1 million unique visitors in 2022.

We do all of this while continuing to innovate with new programs to welcome new voices and honor diversity, equity, and inclusion. The Editorial Fellows and Board Fellows programs provide access and mentorship to rising experts at the early stages of their careers. These programs complement our Leonard M. Rieser Award, the capstone of the Next Generation Program.

Your generous support allows us to meet today's overwhelming challenges and engage audiences yearning for fact-based discussions about science's greatest opportunities and challenges.

We are growing because there is an urgent demand for what we do. Thank you for allowing us to respond to that demand. It matters.

A handwritten signature of Rachel Bronson in dark ink.

Rachel Bronson





# Amnesia Atómica NYC

## Stockpile

A new participatory work by Pedro Reyes in which a portion of 12,075 rocket shaped balloons—equivalent to size of the global nuclear arsenal—were handed out to the public daily.



**“Yes, that mushroom cloud balloon in Times Square is meant to make you stop and think.”**

Between May 17 and May 24, 2022, in partnership with Times Square Arts, the Bulletin presented a multimedia exposition on reducing the dangers of nuclear weapons. Pedro Reyes' inflatable mushroom cloud sculpture, ZERO NUKES, was the centerpiece.

In that one-week period, some 1.5 million people had the chance to experience various aspects of Amnesia Atómica NYC. Presenting the exhibition at Times Square allowed the Bulletin and other nuclear-focused organizations to engage with the public about reducing nuclear risks.

During the event, the Bulletin organized a Mobilization Expo that showcased artists, activists, and organizations offering hands-on activities, virtual reality experiences, information booths, and merchandise to involve those passing through Times Square. Throughout the city, a series of public programs and events spotlighted the work of activists and organizations involved in non-proliferation and disarmament.

Bulletin President and CEO Rachel Bronson told *The Gothamist* that we are trying to engage the public and give them ways to act—to become committed enough to talk to our leaders and try to change the direction that we're going. “Right now, we're entering an arms race 2.0 that is dangerous, expensive, and wasteful,” she said.

Amnesia Atómica was curated by Pedro Alonzo, who specializes in ambitious artworks in public spaces. Inspiration for Amnesia Atómica was sparked at an incubator created by N Square, a network of innovators committed to ending the nuclear threat.

A May 17 press event hosted by Times Square Arts featured Nobel Peace Prize recipient Beatrice Fihn and Mitchie Takeuchi, a second- and third-generation Hiroshima survivor and producer of “The Vow from Hiroshima.”

Thirty news outlets including *The Art Newspaper*, *Frieze*, *Artnet News*, *WNYC* and others published articles with headlines such as “Yes, that mushroom cloud balloon in Times Square is meant to make you stop and think.”

The Bulletin extends an enormous thanks to artist Pedro Reyes, curator Pedro Alonzo, Times Square Arts Alliance, the 13 organizations that joined the Bulletin in engaging with the public in Times Square during the Mobilization Expo, and its many financial supporters including the Bancel Foundation, Carnegie Corporation of New York, N Square, Abakanowicz Arts and Culture Charitable Foundation, David Rockefeller Fund, Lisa Tung and Spencer Glendon, Miner/Nagy Family, and The Prospect Hill Foundation, among others.



**1.** A two-day event within the exhibition week organized by the Bulletin showcased artists, activists, and organizations.

**2.** Hands-on activities, virtual reality experiences, information booths, and merchandise attracted people passing through Times Square.

**3.** Musicians performed as part of the daily live events curated by The Tank, a small, Manhattan-based arts non-profit.

## The people who brought Amnesia Atómica to life



### Pedro Reyes Artist

An artist and activist who has received international attention for his work addressing social, environmental, political, and educational issues. Reyes reframes complex topics in a playful, passionate, and accessible way.



### Mitchie Takeuchi Keynote Speaker

An activist, a second- and third-generation Hiroshima survivor, and the producer of *The Vow from Hiroshima* (2019). Takeuchi grew up in Hiroshima and has made New York City her home for more than 25 years as a media consultant.



### Pedro Alonzo Curator

An independent curator who specializes in working with artists to develop ambitious artworks in public space.



### Jean Cooney Host

The director of Times Square Arts, the public art program of the Times Square Alliance, which is the largest public platform for innovative contemporary performance and visual arts. Times Square Arts hosted *Amnesia Atómica*.

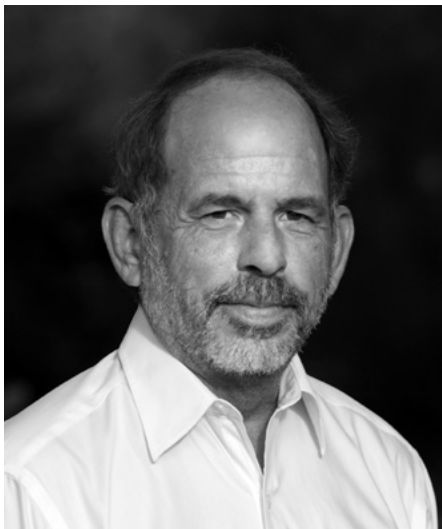


### Beatrice Fihn Keynote Speaker

Executive Director of the International Campaign to Abolish Nuclear Weapons (ICAN), the 2017 Nobel Peace Prize-winning campaign coalition that works to prohibit and eliminate nuclear weapons. She accepted the Nobel Peace Prize and delivered the Nobel Lecture in Oslo on behalf of the campaign.

# From the Editor-in-Chief

## John Mecklin



### A year of remarkable growth

The Bulletin continued to grow at a remarkable pace in 2022, surpassing its previous readership record (set in 2021) by more than 40 percent. Some 6.1 million readers came to our website last year, an increase of almost 1.8 million readers from the previous year (which itself was a record for Bulletin readership). This enormous jump in traffic can be attributed to the impressive array of investigative journalism and expert analysis the editorial staff published across our coverage areas.

That coverage was of course led last year by a wide variety of reportage on and analysis of Russia's invasion of Ukraine and veiled threats from Russian leaders about the potential use of nuclear weapons. The response of Bulletin readers was immediate and overwhelming: Our website had more than 1.2 million unique visitors in February 2022, the first month of the invasion, reflecting an increase of more than 300 percent over the preceding February.

Two articles stood out in terms of readership over the course of 2022. After months of research, Bulletin nuclear affairs editor François Diaz-Maurin published an investigative report, "Nowhere to hide: How a nuclear war would kill you—and almost everyone else," that quickly became a worldwide sensation, in large part because of its relevance to the war in Ukraine.

Since its publication in October, the article has garnered more than 560,000

pageviews. An article written by biosecurity editor Matt Field detailed another frightening aspect of the Ukraine conflict. "US official: Russian invasion of Ukraine risks release of dangerous pathogens," logged more than 480,000 pageviews.

But many other Ukraine-related stories garnered more than 50,000 views this year, often many times more. Among them, a few stand out: An interview with one of Ukraine's most-followed journalists, Illia Ponomarenko, has more than 90,000 pageviews and provides a glimpse into the day-to-day horror and hope experienced on the ground, as the war drags on without a visible endpoint. An early and solemn assessment of the possibility that Russia will use nuclear weapons in Ukraine—by Francesca Giovannini of Harvard's Belfer Center for Science and International Affairs—was both eloquent and widely read, with more than 55,000 views. And the Nuclear Notebook column on Russian nuclear forces, published in the war's early days, was obviously of intense interest, attracting more than 134,000 pageviews, thanks in part to creative promotion by our digital team.

Even beyond the annual Doomsday Clock announcement and the Ukraine war, the Bulletin's impact was obvious, wide, and deep throughout last year. More than 14,000 sites referred readers to Bulletin content during 2022. Many of the top traffic sources were social media sites, including the industry giant Facebook and specialized aggregating sites like Reddit, SmartNews, and Hacker News. The Bulletin continued to gain referral traffic from web-native news sites like vox.com, vice.com, politico.com and slate.com and authoritative legacy media—including *The Washington Post*, *The Guardian*, *The New York Times*, NPR, and the BBC. As usual, a Who's Who of prominent think tanks and public interest foundations also referred traffic to thebulletin.org in the first eight months of the year, including the Brookings Institution, the Carnegie Endowment, the Federation of American Scientists, the Council on Foreign Relations, and Harvard's Belfer Center for Science and International Affairs.

Because of two major multi-year awards to the Bulletin, the editorial department expanded last year, adding an associate editor position and an associate multimedia editor position. Meanwhile, Matt Field,

who had been our associate editor over disruptive technologies, has moved to take over as editor for biosecurity, a new role created to accommodate expanded coverage of biological threats. This includes a major partnership/collaboration with two leading experts, Filippa Lentzos of Kings College London and Greg Koblenz of George Mason University, which led to a multimedia presentation on the world's major biosecurity laboratories.

Our new funding will also allow us to commission top magazine journalists to undertake major investigative projects on biothreats. The first of those projects, "Is the next pandemic brewing on the Netherlands poultry farms?", by Paul Tullis, was published in September.

So let me end, once again, by summarizing the incredibly good Bulletin news: In an era when many media outlets are under enormous financial pressure, scaling back editorial staffs or closing their doors, the Bulletin of the Atomic Scientists is—year after year, and especially now—thriving. There are a lot of reasons for our success, but all of them lead back, directly or indirectly, to you, our supporters, who believe in our mission—a mission that, as the invasion of Ukraine has so horribly shown, remains vital to international security—and provide the means to carry it out.

With your continued backing, we will find new and powerful ways to tell the stories of humanity's most important and interesting pursuit: survival.

A handwritten signature in dark ink, appearing to read "John Mecklin".

John Mecklin



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## Ukraine commands Bulletin attention

The Bulletin team grew to meet the rising demand for original content and first class analysis, and worked around the clock to add new features and social media platforms, and create inroads to new audiences throughout 2022. (See page 13 to meet new staff members.)

Russia's war on Ukraine was a major focus of the Bulletin's coverage, well beyond the mass media attention to troop deployments, casualties, and maps. Bulletin experts described the potential outcomes if Russia actually used nuclear weapons; deftly refuted Russia's bogus claims that the US planned to use bioweapons; and provided background to Russia's precept "escalate to de-escalate." The Bulletin also covered how the conflict damaged the Ukrainian landscape and threatened European efforts to transition to low-carbon technologies with minerals mined in Russia.

### Risking release?

The Russian invasion of Ukraine could put at risk a network of US-linked labs in Ukraine that work with dangerous pathogens, according to Robert Pope, the director of the Cooperative Threat Reduction Program, a 30-year-old Defense Department program that has helped secure the former Soviet Union's weapons of mass destruction and redirect former bioweapons facilities and scientists toward peaceful endeavors.

### Treaties still matter

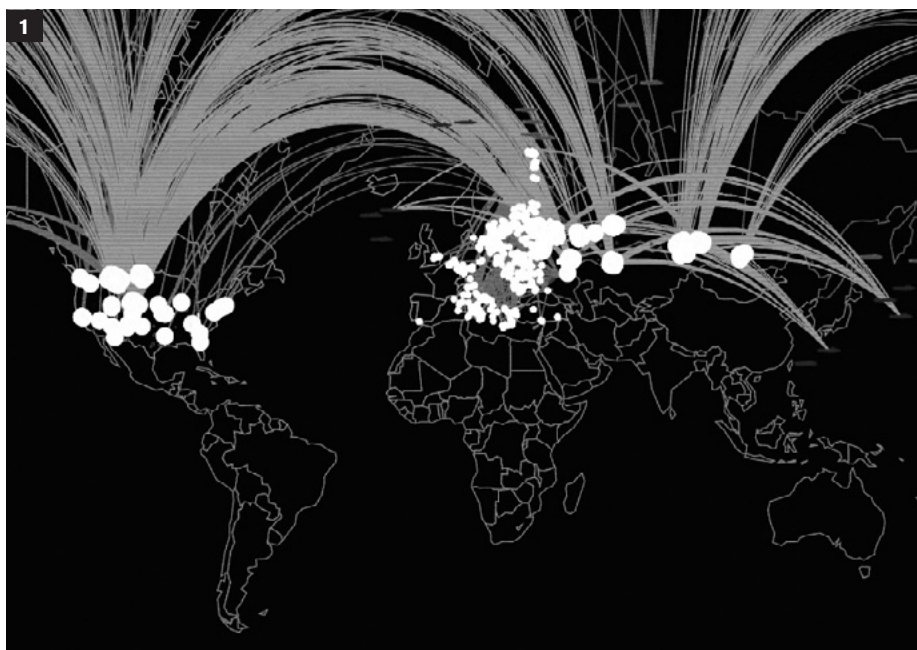
Even through fraught conditions, Rose Gottemoeller, former NATO Deputy Secretary General and US State Department official, said in a November article that throughout the COVID-19 pandemic, the US and Russian Federation worked quietly to keep the implementation of New START on track, despite health-related suspension of inspections and Russia's nuclear saber-rattling in Ukraine.

### Nowhere to hide

Bulletin staff members worked together to deliver "Nowhere to Hide: How a nuclear war would kill you—and almost everyone else" by associate editor François Diaz-Maurin with design by multimedia editor Thomas Gaulkin. Editor-in-Chief John Mecklin and his team conceived the project to bring new research on nuclear winter by renowned scholar Alan Robock and his colleagues to a broad audience. The goal was to contextualize Robock's recent work, along with his extensive body of research, and commemorate the 60<sup>th</sup> anniversary of the Cuban Missile Crisis. The article was also intended to serve as a public service announcement of sorts, to correct reckless language suggesting that a nuclear war is winnable and survivable.

The October article passed 500,000 pageviews in two weeks, with 269,000

coming in the first day alone, making it the Bulletin's third most read article of all time and our most read nuclear focused article ever. The communications and digital team promoted the article in our newsletter to news aggregators and journalists, and on social media.



1. Still photo from "Plan A", a video simulation of an escalatory nuclear war between the United States and Russia. Credit: Alex Glaser / Program on Science and Global Security, Princeton University

2. US Air Force personnel perform a simulated missile reduction in accordance with the New Strategic Arms Reduction Treaty. Credit: Photo US Air Force/Airman 1st Class Desiree Esposito via Flickr

3. A research lab in Kyiv, Ukraine built by the Cooperative Threat Reduction Program. Credit: Defense Threat Reduction Agency

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## Climate change

### Getting serious about climate change

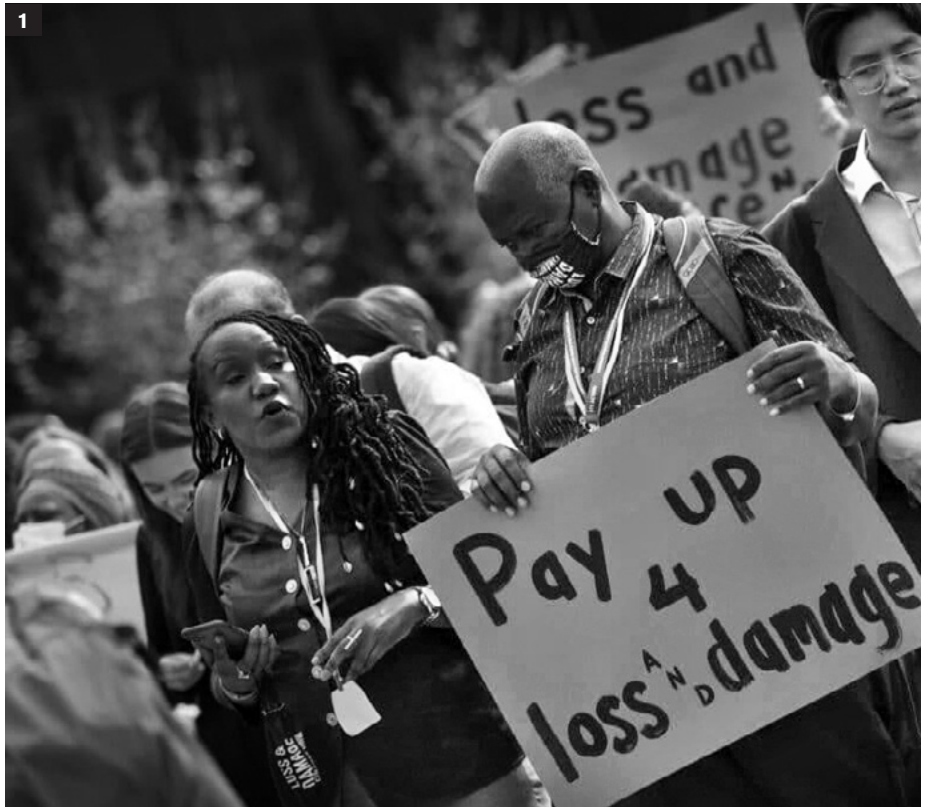
If you had polled a random sample of climate experts and insiders ahead of COP27 on which issue was most likely to bring the negotiations crashing down, most would have given the same answer: the plan to raise money to address climate impacts in developing countries, otherwise known as loss and damage.

Instead, it was the crowning achievement in Sharm el-Sheikh, according to a December update from Taylor Dimsdale, senior fellow for climate and disaster resilience at Fors Marsh. Participants reached an agreement to establish a new fund to help developing countries cover the cost of climate impacts. They also set up a new institution, called the Santiago Network, which will provide technical assistance to vulnerable countries.

### Energy crisis in Ukraine threatens

Fear over a possible nuclear disaster at the Zaporizhzhia nuclear power plant in Ukraine rose in August, as both Russia and Ukraine warned that the other side could be planning a “false-flag” attack, according to Jessica McKenzie, associate editor at the Bulletin. Russian forces—currently in control of the plant—have ordered many of the Ukrainian workers who continue to run and operate the plant to stay home from work; only those workers who work on the power units themselves have been allowed on the premises, according to Ukraine’s state-run energy firm, Energoatom. The European Union and the United States have called for Zaporizhzhia and the surrounding area to be demilitarized, but Russia has rejected the suggestion, saying it would make the plant “even more vulnerable.”

McKenzie interviewed Oleh Savitskyi, a board member of the non-governmental organization Ecoaction and a climate and energy policy expert with the Ukrainian Climate Network who worked in the ministry of energy and environment protection of Ukraine until June. He warned about a number of factors: “There could be a real deficit of energy supply in the winter and Ukraine will be much more vulnerable to Russian attacks on energy infrastructure.”



1. Demonstrators with signs at COP27.

Credit: UN Climate Change Flickr

2. Zaporizhzhia nuclear power plant in southern Ukraine. The two tall smokestacks are at a coal-fired generating station about 3km beyond the nuclear plant.

Credit: Ralf1969, Wikimedia Commons.



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## Disruptive tech and misinformation



### Killer robots? Now what?

Using pictures out of Ukraine showing a crumpled metallic airframe, open-source analysts of the conflict there say they have identified images of a new sort of Russian-made drone, one that the manufacturer says can select and strike targets through inputted coordinates or autonomously. In other words, analysts appear to have spotted a killer robot on the battlefield.

In his March analysis, national security consultant Zachary Kallenborn asked what the global community should do, pointing out that international norms around autonomous weapons are quite nascent, and that large, powerful countries, including the United States, have pushed back against them. Even if there were broadly accepted norms, it's not clear how much more could be done, he argued.

### "The Big Lie" jeopardizes democracy

In the 19th and 20th centuries, disinformation about African-Americans, propagated in newspapers and in other venues, helped justify legal segregation of schools, restaurants, drinking fountains, swimming pools, and other public spaces. In a sharp analysis published in May, Editorial Fellow Angela Pashayan pointed out that "since then, racists in the United States—from dog whistlers to outright white nationalists—and adversarial countries like Russia have been able to exploit the fissures in US society that racial disinformation helped crack open, creating a vicious spiral, in which racist disinformation helps to beget real-world racism, which then

creates ripe targets for more disinformation that exploits racial division." For example, disinformation undergirded former President Donald Trump's false claim that he won the 2020 election and that massive voter fraud put President Joe Biden over the top. "After all, in Trump's telling, it was vote rigging in urban centers, where many Blacks live, that helped Biden win," said Pashayan.

### Will AI destroy art?

Associate Editor Sara Goudarzi asked experts from a variety of artistic and technical disciplines to weigh in on the ethical, economic, and artistic implications of art created by intelligent machines. AIs were not asked to contribute to the conversation, but AI tools were used in generating images that appeared in the articles. Writer, artist, and curator Katie Peyton Hofstadter maintained that we, not AI, are choosing our artistic future. Like other technologies that have come before it, artificial intelligence, commonly known as AI, is changing art forms that have existed for millennia. It will also be instrumental in the creation of art forms not yet imagined, she said.



1. A screenshot of the loitering munition known as the KUB-BLA in English. Credit: Kalashnikov Group
2. Disinformation about African-Americans was used to justify the legally enforced segregation of the Jim Crow era in the United States. Credit: Russell Lee, Wikimedia Commons
3. Illustration generated by OpenAI's DALL-E 2

# Monitoring and managing biorisks

## Biolabs to be tracked worldwide



### Mapping high-containment labs

In 2022, the Bulletin partnered with GlobalBiolabs, an initiative to provide transparency around high-containment labs worldwide, and their policies and practices to ensure safe, secure, and responsible pathogen research. The Bulletin collaborated with researchers from King's College London and George Mason University to re-launch their map of biosafety level 4 (BSL-4) and BSL-3+ labs around the world.

For countries with BSL-4 labs, the map now includes scores that assess a country's approach to biorisk management and the country's national governance and stability. The map presents the most recent research findings and will serve as a tool for developing policy recommendations to strengthen biorisk management in BSL-4 labs.

In September 2022, the Bulletin convened a group of scientists and public health leaders to launch an international taskforce to consider trends and oversight of high-risk pathogen research. This followed the WHO's release of the "Global guidance framework for the responsible use of the life sciences: mitigating biorisks and governing dual-use research."



**1.** Researcher Kristie Oxford harvesting a virus for global systems biology analyses. Credit: Andrea Starr, Pacific Northwest National Laboratory

**2.** The interactive GlobalBiolabs map launched in September 2022. Design: Erik English



# Monitoring and managing biorisks

## Comprehensive global approach sought

### Collaboration to address outbreak risks

In "The Pathogen Project: Creating the Framework for Tomorrow's Pathogen Research," participants are discussing risk assessment and mitigation, including lab-based outbreak risks. A public-facing conference in Geneva, Switzerland, on April 19-21, 2023, will include task force members, policy leaders, journalists, scientists, and civic leaders, among others, working to produce a summary report with recommendations for a new global approach to management of extremely high-risk biological research.

"As biological research advances our safeguards must also advance. As a scientific community, we need clear norms and prohibitions for dangerous materials and practices," said project co-chair Ameenah Gurib-Fakim, the sixth president of the Republic of Mauritius (2015-2018) and the first woman to hold that office. She is joined in leading the project by fellow co-chairs Ravindra Gupta, professor of clinical microbiology at the Cambridge Institute for Therapeutic Immunology and Infectious Diseases; Shahid Jameel, Sultan Qaboos bin Said, fellow and principal investigator, "Project on Public Health, Science and Technology in Muslim Societies" at the Oxford Centre for Islamic Studies; and David Relman, Thomas C. and Joan M. Merigan professor in medicine, professor of microbiology and immunology, and senior fellow at the Center for International Security and Cooperation at Stanford University. Relman is also on the Bulletin's Science and Security Board.

"The project is not meant to be the final word on the issue. Rather, our aim is to catalyze an inclusive and broad discussion among scientists and other interested stakeholders of the risks and benefits of potential pandemic pathogen research, and how such research may be conducted in a maximally de-risked manner," said Jesse Bloom, project co-director, professor at the Fred Hutchinson Cancer Center, and Investigator of the Howard Hughes Medical Institute.

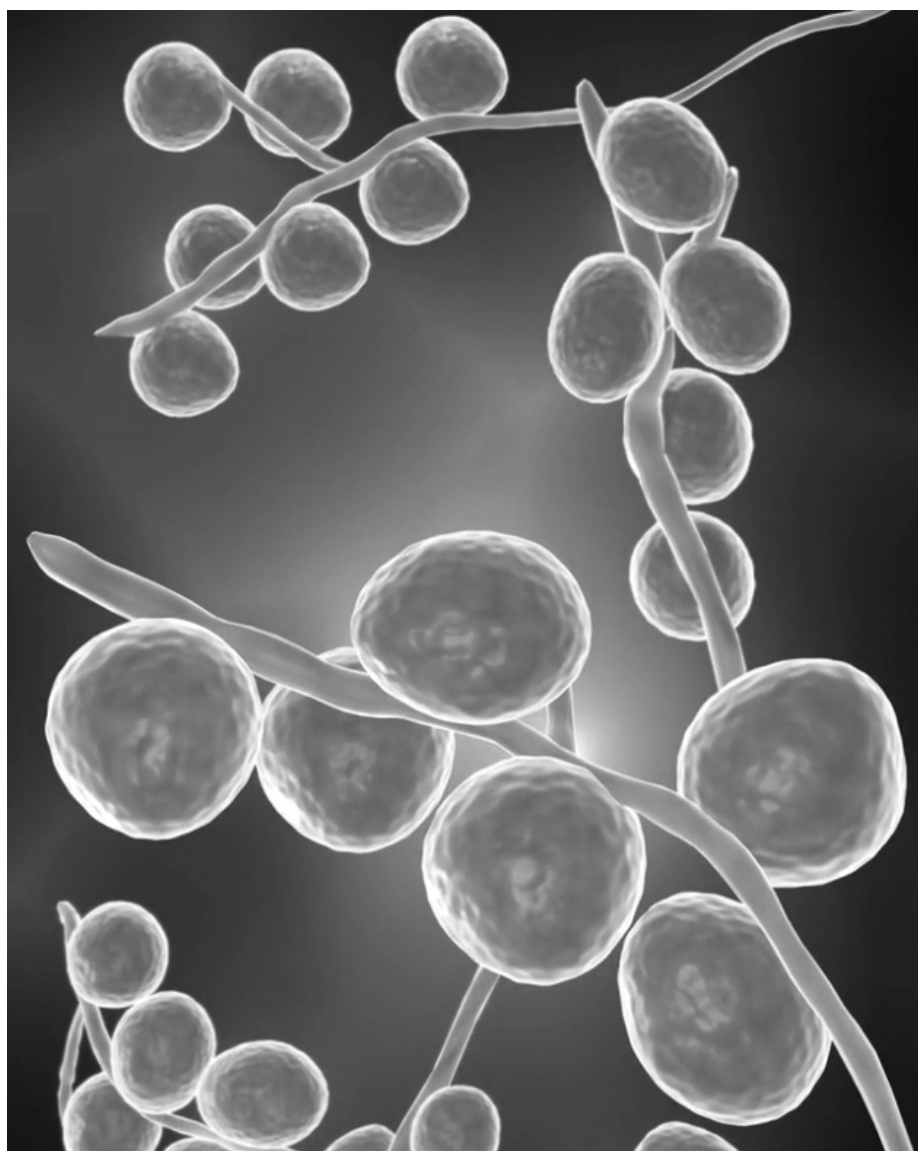
Fellow co-director of the project and Reader (associate professor) in Science & International Security at King's College London, Filippa Lentzos, said, "We believe that creating a new forum for an international network of experts that crosses

disciplines is a crucial step in developing responsible and sustainable practices to mitigate risks of both lab-based and zoonotic outbreaks, and to reducing the chances that we or future generations will suffer through another pandemic as devastating as COVID-19."

"We are very excited to partner with the taskforce's leaders and funders like Bill and Amy Gurley on this project," said Rachel Bronson, president and CEO of the Bulletin, which is organizing the project. "Since our founding, one of the Bulletin's key goals has been to provide a forum for science leaders to examine the broader implications of their research."



Pathogenic Candida yeast. Credit: Artur Plawgo/Science Photo Library



# The Magazine

## Reaching new readers

The Peloponnesian War. Bitcoins. Space. Social shaming. Microchips in humans. Wood bioenergy. The 30<sup>th</sup> anniversary of "The End of History."

These diverse topics have at least one thing in common: Each was the subject of an article in the Bulletin's premium, bi-monthly magazine this year. And each made the short-list of the Bulletin's best magazine coverage of 2022.

The magazine seeks a variety of expert voices, coming from across the globe, to comment on what is happening in the world, even before a big news event—such as the invasion of Ukraine or the collapse of Bitcoin—breaks.

We also present articles in different formats, from investigative pieces like Jessica McKenzie's July article "How bitcoin makes burning fossil fuels more profitable than ever," to interviews such as the one with Francis Fukuyama on the 30<sup>th</sup> anniversary of his book *The End of History*, as well as think pieces such as Robert Daly's "China and the United States: It's a Cold War, but don't panic."

We include fresh takes from new and unexpected outside sources. For example, essays about sanctions on Russia have included the perspective of a sociologist—who has found compelling evidence that the social shaming of Putin's elite inner circle (along with freezing and seizing their assets) may be just as powerful as more traditional tools in weakening the regime.

At the same time, each individual issue maintains a cohesiveness—so that, for example, the March issue on Taiwan has a Nuclear Notebook devoted to how many nuclear weapons China has.

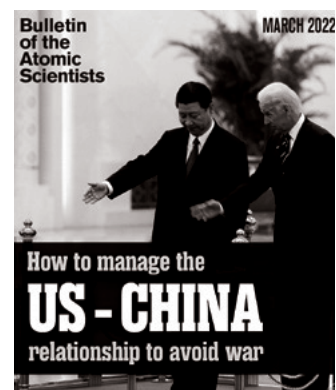
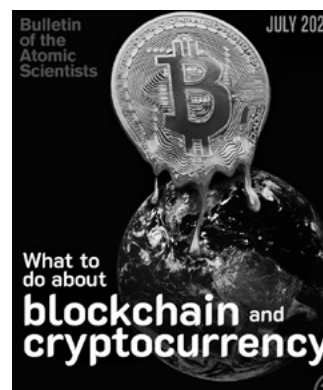
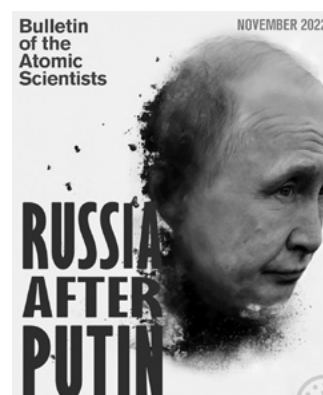
These efforts are paying off. According to our publishing house, Taylor and Francis, there were 21,240 more PDF downloads of Bulletin magazine articles from their site in the second quarter of 2022 (April to June) than there had been in the same quarter the previous year—an increase of just over 33 percent.

Magazine subscribers also have access to the complete Bulletin archive, which contains every article published since our founding in 1945. This archive was created in honor of John A. Simpson, one of the Bulletin's principal founders and a longtime member of the Board of Sponsors.

This searchable archive provides exclusive online access to original interviews and commentary by luminaries such as Albert Einstein, J. Robert Oppenheimer, Jennifer Doudna, John F. Kennedy, Stephen Hawking, Christine Todd Whitman, US Secretary of Defense William J. Perry, and multiple Nobel laureates.

The Bulletin has continued to present the digital magazine issues with provocative, well-designed covers, some of which have been used for posters and T-shirts available for purchase in the Bulletin store.

Magazine cover designs by Thomas Gaulkin



# Welcoming new staff

## Increasing staff capacity to meet demand

Strategic focus, increased funding, and first-rate content combined in 2022 to drive significant growth and impact in website traffic. The chart to the right shows our evolution over the past four years. To achieve this growth, the Bulletin shifted and promoted current staff members, and welcomed a dazzling group of talented professionals, two of whom live outside the US.

As part of our transformation, **Matt Field** was promoted to editor, biosecurity, and **Sara Goudarzi**, whose work has appeared in *Scientific American*, *The New York Times*, and *National Geographic News*, succeeded Matt as associate editor, disruptive technology. We have also added a second associate multimedia editor, **Erik English**, who resides in Vienna.



**“Strategic focus, increased funding, and first-rate content combined in 2022 to drive significant growth and impact in website traffic.”**

We recruited **François Diaz-Maurin** from Barcelona to cover our nuclear beat. François' connections in the nuclear field allowed him to produce top-level nuclear coverage from the moment he began. Given the terrifying moment of today's nuclear reality, the timing of François' joining us was propitious.



**John Pope** joined the Bulletin in August from ReThink Media as chief audience officer. John's deep expertise in audience development and outreach is expected to broaden the Bulletin's community considerably. As one of his first acts, he hired **Avery Restrepo** as social media coordinator. **Sarah Starkey** has been promoted to brand manager.



The Bulletin also welcomed **Dainese Chandra** as advancement services coordinator, **Danielle McMann-Griffin** as executive assistant/project manager, and **Deisy Hernandez** as bookkeeper.

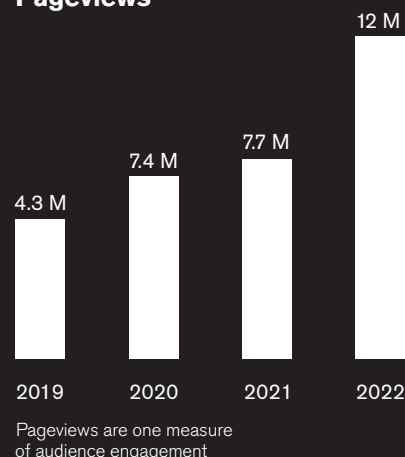


The Bulletin bade a fond farewell to retiree and former chief financial officer **Lisa McCabe**, who was succeeded in that position by **Jim White**. McCabe, who served with distinction during a 12-year period of growth and transition for the Bulletin, continues to offer trusted counsel to her former colleagues, for which we are very grateful.

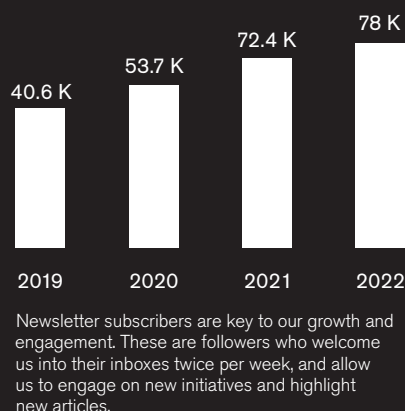


### Bulletin website and follower statistics

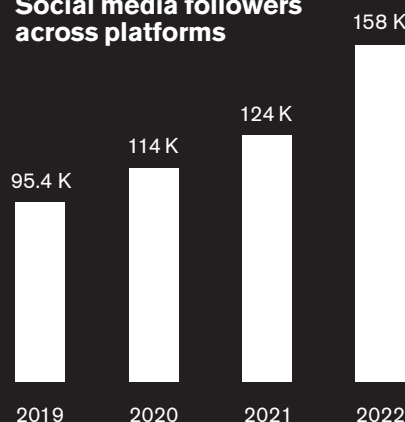
#### Pageviews



#### Newsletter subscribers



#### Social media followers across platforms





# 2022 Rieser Award recipients

## Haydn Belfield and Christian Ruhl

The Bulletin named Haydn Belfield and Christian Ruhl as the 2022 recipients of the Leonard M. Rieser award for their July 14, 2022, article, "Why policy makers should beware claims of new 'arms races'".

"Via insightful analyses of unfortunate historical arms races, Haydn Belfield and Christian Ruhl make a compelling argument against repetition of the costly and dangerous reactions to supposed international threats that have unfortunately afflicted US defense policy for decades," Bulletin editor-in-chief John Mecklin said. "While calling for more thoughtful US responses to global competition in artificial intelligence, hypersonic weapons, information technology, and other realms, Belfield and Ruhl acknowledge that '[n]ot all 'sprints' for new military technologies are mistaken, and not all mistaken sprints are suboptimal or dangerous.' In so doing, they exhibit exactly the type of sophisticated, reality-based thinking and elegantly balanced writing that the Rieser Award is designed to honor."

For the past six years, Haydn Belfield has been a research associate and academic project manager at Cambridge University's Centre for the Study of Existential Risk. There, he advised the UK, US, and Singaporean governments; the EU, UN and OECD; and leading technology companies. Most of his work is on the security implications of artificial intelligence (AI). Key publications include "The malicious use of AI: Forecasting, prevention, and mitigation" and "Toward trustworthy AI development: mechanisms for supporting verifiable claims." He is an associate fellow at the Leverhulme Centre for the Future of Intelligence. Previously he worked in UK politics as the senior parliamentary researcher to a MP in the Shadow Cabinet and was seconded to several general election and referendum campaigns. He is a DPhil/PhD Candidate in International Relations, and he has an MSc in Politics Research and a BA in PPE, all from Oxford University.

Christian Ruhl is a senior researcher at Founders Pledge, a community of technology entrepreneurs dedicated to finding and funding high-impact interventions related to some of the world's most pressing problems. Christian is also the fund manager for Founders

Pledge's Global Catastrophic Risks Fund. His research focuses on international security, emerging technologies, weapons of mass destruction, and global catastrophic risks broadly defined. Before joining Founders Pledge, Christian was the program manager for the research theme on "The Future of the Global Order: Power, Technology, and Governance" at Perry World House, the University of Pennsylvania's global affairs think tank. After receiving his BA from Williams College, Christian studied on a Herchel Smith Fellowship at the University of Cambridge for two master's degrees, one in History and Philosophy of Science and Medicine, and one in International Relations and Politics, with dissertations on early modern submarines and Cold War nuclear strategy.

### Leonard M. Rieser

The Rieser Award, named for former Bulletin board chair Leonard M. Rieser, is the capstone of the Next Generation Program. The program was created to ensure that new voices have a trusted platform from which to address existential challenges posed by nuclear risk, climate change, and disruptive technologies.

Rieser was the Bulletin's board chair from 1984 until his death in 1998. He was a graduate student at the University of Chicago when he worked on the Manhattan Project and went on to a distinguished academic career as a professor and provost of Dartmouth College.

Rieser championed emerging scientists and policy leaders and believed in their ability to play a critical role in the resolution of persistent global security problems. We continue to work with his family, and other longtime friends and donors, to extend his legacy.

The Rieser Award includes the opportunity to speak at the Bulletin's marquee event, Conversations Before Midnight, and a \$1,000 prize. Christian Ruhl has declined his share of the monetary prize to avoid potential conflicts of interest with his work for the Global Catastrophic Risks Fund. The monetary award has therefore been directed in full to Haydn Belfield.



1. Haydn Belfield  
2. Christian Ruhl



## Not so fast...

### Rieser Award-winning essay



Claims of new “arms races” are everywhere these days. The world has supposedly entered a new space race, with Russian and Chinese anti-satellite weapons posing new threats to space-based infrastructure. The United States and China are also, allegedly, in an AI race, competing to build more powerful artificial intelligence systems. Let’s not forget the cyber arms race. Oh, and the hypersonic weapons race.

Under the specter of renewed great power competition, fears of a new arms race or an adversary’s imminent technological superiority are common. Vigilance is critical; an aggressive Chinese Communist Party and a revisionist Russia are both very real threats to the world—as Uyghurs and Ukrainians alike know painfully well—and the United States must remain prepared against expansionist authoritarian regimes.

Nonetheless, policy makers should examine new claims of a “race” in critical technologies dispassionately and rationally and beware of suboptimal arming in response to claims of adversary capabilities. (In the words of political scientist Charles L. Glaser, suboptimal arming occurs when “the state’s decision to launch a buildup is poorly matched to its security environment.”) History—especially the history of nuclear competition—shows that such fears can be overblown and costly, and policy makers

would do well to remember the cognitive and cultural biases that make people see threats where there are none.

Not all “sprints” for new military technologies are mistaken, and not all mistaken sprints are suboptimal or dangerous. There have, however, been mistaken sprints in the past, and American leaders, key scientists, and experts should be careful about mistaken sprints in the future. It is important not to be complacent, but instead to engage in a vigorous accumulation of intelligence about other states’ capabilities and intentions, and a sober assessment of that intelligence—without being swayed by alarmist voices. The consequences of not doing so could be catastrophic.

#### The missing “missile gap”

In the late 1950s, key US experts were convinced that they “were again in a desperate race with a powerful, totalitarian opponent,” wrote Daniel Ellsberg, a former RAND employee and presidential nuclear advisor, in his 2017 memoir *The Doomsday Machine*. They believed the Soviets had a lead in intercontinental ballistic missiles (ICBMs)—the “missile gap.” With that supposed advantage, the Soviets could blackmail the world or even launch a successful preemptive strike on the United States. So, these experts advocated for and participated in an ICBM sprint.

However, their fears were mistaken. The 1961 National Intelligence Estimate, as Ellsberg later revealed, calculated that “the Soviets had exactly four ICBMs, soft, liquid-fueled missiles at one site, Plesetsk. Currently we had about forty operational Atlas and Titan ICBMs [...] the numbers were ten to one in our favor.” Therefore, the United States’ sprint for ICBMs was not necessary to deter the Soviet Union from using its advantage to launch a first strike. Instead this sprint hastened the advent of ICBMs and the situation we are now in—in which a president has only minutes to decide how to respond to a warning of an attack.

Dissenting opinions (for example, from the Army and Navy) on the missile gap were sidelined, and information on the actual state of the Soviet forces kept secret for years. Better intelligence assessment could have delayed the development and deployment of these immensely destructive weapons. Later, key participants such as Ellsberg described their involvement as the greatest mistake of their life.

Cyber support to 1st Cavalry Division at National Training Center, Credit: U.S Army Cyber Command

# Not so fast...

## Rieser Award-winning essay

### The nonexistent Nazi bomb

Nearly 20 years earlier, the key motivation for most of the scientists—like Albert Einstein, Enrico Fermi, and Leo Szilard—who advocated for and participated in the United States' sprint for an atomic bomb was concern that the Nazis were themselves developing an atomic bomb. The Nazis could not be allowed a monopoly on such a destructive weapon.

However, these fears were also mistaken. We now know that, in June 1942, Hitler decided against a sprint. Armaments chief Albert Speer and nuclear physicists who worked on Germany's bomb program thought it would take three to four years to deliver—too late to make a difference to the war. Moreover, the Nazis needed raw materials and manpower elsewhere for armaments production, so they faced real resource constraints.

The Manhattan Project did not need to, and did not in practice, deter Hitler from development or use of a nuclear weapon. Instead this sprint brought forward in time the development and deployment of nuclear weapons.

With their limited intelligence about the Nazi program, US nuclear scientists were surely right to advocate for and lead the sprint in 1942. Would these scientists have participated so vigorously had they known that no other state (Germany, Japan, or the Soviet Union) had a serious nuclear program during the war? Better intelligence about the Nazi regime in 1942 could have reduced the need for the Manhattan Project—freeing up vast resources (0.4 percent of the US gross domestic product in 1944) for other war production and delaying the advent of these immensely destructive weapons. Without the US sprint, the Soviets would not have been able to steal its secrets and build their own bomb so quickly. Later, key participants such as Einstein and Szilard described their involvement as the greatest mistake of their life.

The “best and the brightest” of two previous generations mistakenly thought they were in a race, sprinted when they did not need to, and later regretted it. The current generation of experts should not think itself immune to these dangers.



### Misperceptions of AI

Unfortunately, some technologies seem more vulnerable to these dynamics than others. Software-based capabilities, for example, may be more difficult to verify than traditional military technologies.

As the AI expert Missy Cummings has shown, for example, misperceptions of technological advances could be especially insidious for artificial intelligence. As Cummings explains, AI advances are relatively easy for an adversary to fake, but “such a pretense could then cause other countries to attempt to emulate potentially unachievable capabilities, at great effort and expense. Thus, the perception of AI prowess may be just as important as having such capabilities.”

We can see this perception, for example, in some of the frothier warnings about an “AI gap” with China that have made the rounds in Washington. In reality, the United States and its allies and partners continue to dominate the semiconductor supply chain, high-impact AI research, and AI talent (more than 85 percent of Chinese PhD students in the United States intend to, and do, stay in the country after graduation).

US experts should not be complacent about this lead, but they do not need to panic. Policy makers should remember the lessons of the past, and approach new claims of technological superiority with care, and perhaps a healthy dose of skepticism.

# Doomsday Clock Announcement

## “Get to work” UN Secretary Guterres tells world leaders

Reflecting the urgency of the moment, Bulletin leaders opened a fast-paced two days in January 2023 with the live Clock Announcement on January 24 from the National Press Club in Washington, DC. Finding the world to be at a higher risk than it was last year at this time, the Bulletin's Science and Security Board announced that it had set the Doomsday Clock 10 seconds closer to the metaphorical endpoint.

“If there was ever a time for world leaders to take actions to turn back the Clock, it's now. Until then, it is 90 seconds to midnight,” said Science and Security Board co-chairs Daniel Holz and Sharon Squassoni in a CNN op-ed with Executive Chair Jerry Brown on January 24.

The impact was both immediate and lasting. Beyond Washington and other world capitals, millions of citizens learned more about the dire conditions we face, in news alerts and social media. Worldwide attention far exceeded that of previous announcements. (See the following page for coverage statistics.)

Nearly two weeks after the announcement, UN Secretary-General António Guterres told the world: “This is the closest the Clock has ever stood to humanity's darkest hour—closer than even during the height of the cold war.”

### Briefings follow Clock Announcement

The announcement itself on January 24 was followed by a media Q&A, a leadership luncheon co-hosted with The Elders for scientists and international dignitaries, and two panels at Georgetown University, one that featured members of The Elders with Bulletin CEO and President Rachel Bronson that was live streamed, and a second featuring Board of Sponsors Chair Sig Hecker, and Science and Security Board members Herb Lin and Suzet McKinney.

On January 25, Bulletin leaders hosted a staff briefing on Capitol Hill in partnership with the Center for Non-Proliferation and Arms Control and the American Academy of Arts and Sciences that featured Hecker along with Science and Security Board members Sharon Squassoni and Scott Sagan and was moderated by former member of Congress John Tierney. That briefing drew just shy of 50 Hill staffers, from both parties in the House and Senate.

### How the Clock is set

The time on the Clock is set every year by the Bulletin's Science and Security Board based on their collective answer to two questions: is humanity safer or at greater risk this year, compared to last year, and is humanity safer or at greater risk this year compared to the 75 years we have been asking the question.

The setting was due largely but not exclusively to Russia's invasion of Ukraine and the increased risk of nuclear escalation. The new Clock time was also influenced by continuing threats posed by the climate crisis and the breakdown of global norms and institutions needed to mitigate risks associated with advancing technologies and biological threats such as COVID-19.



1. At the Clock Announcement, from left: Siegfried Hecker, Daniel Holz, Sharon Squassoni, Mary Robinson, and Elbegdorj Tsakhia. Credit: Jamie Christiani  
2. General Assembly Hears Briefing by Secretary-General on His Priorities for 2023. Credit: UN Photo/Mark Garten  
3. At first briefing at Georgetown, from left: Katherine Collin, Juan Manuel Santos, Mary Robinson, Elbegdorj Tsakhia, and Rachel Bronson. Credit: Georgetown University



# Doomsday Clock Announcement

## Gets attention from Capitol Hill to the Kremlin

### Global engagement

#### Day of pageviews

**572,847**

#### The day following pageviews

**371,994**

#### First week following the “announcement” pageviews

**1,480,021**

### Video

Combining the Bulletin's YouTube and others that streamed the video, such as Reuters, the announcement had over 120k views in the first 24 hours.

### Social Media

The Doomsday Clock reached the number one trending topic in the US on Twitter. Later that day it fell to third and held there for much of the day, with everyone from Senator Edward Markey to Wacka Flocka tweeting about it.

#### Within one week, the numbers of Bulletin followers grew by

**6%**

Twitter

**14%**

TikTok

**18%**

Instagram

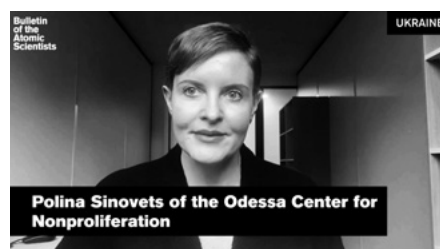
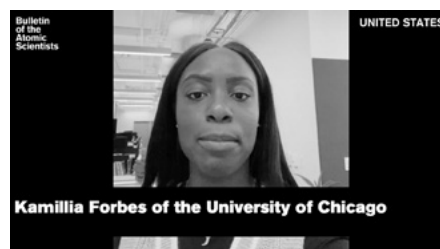
### Collaborations

To stimulate engagement with the Clock message, our Digital team hosted a first-ever briefing for social media influencers in mid-January where we shared visual assets and a creative brief. About a dozen influencers posted materials.

More than 40 issue-oriented groups indicated an interest in receiving materials with groups like Global Zero, ICAN, the European Leadership Network, the Sierra Club Canada Foundation, NTI, and many others, finding ways to reach out around the Doomsday Clock.

We also highlighted seven organizations and activists in the announcement video itself. Each representative stated why he or she intended to watch the Doomsday Clock Announcement. (See below.)

An initial estimate shows that these collaborations generated 300,000 views on Twitter with many groups also taking the messaging to other platforms, including traditional media op-eds and Letters to the Editor, and some groups even using it for in-person event programming.





# Doomsday Clock Announcement

## A time of unprecedented danger

### Worldwide media: a sampling

#### AlJazeera

Symbolic Doomsday Clock moves closer to midnight amid Ukraine war

#### Axios

War in Ukraine pushes Doomsday Clock forward

#### BBC

Doomsday Clock signals highest ever peril level

#### CNN

The Doomsday Clock reveals how close we are to total annihilation

#### Discover

What is the Doomsday Clock and Why You Should Care

#### The Guardian

Doomsday Clock at record 90 seconds to midnight amid Ukraine crisis

#### The New York Times

Doomsday Clock Moves Closer to Midnight than Ever

#### NPR

The Doomsday Clock moves to 90 seconds, signaling more peril than ever

#### Reuters

Kremlin expresses alarm over 'Doomsday Clock'

#### The Washington Post

Doomsday Clock hits 90 seconds to midnight, its most dire prediction ever



"The Doomsday Clock is sounding an alarm for the whole of humanity. The science is clear, but the political will is lacking. This must change in 2023 if we are to avert catastrophe. We are facing multiple, existential crises. Leaders need a crisis mindset."

#### Mary Robinson

Chair of The Elders, former UN High Commissioner for Human Rights, and Former President of Ireland



"As a former President of a country landlocked between two large powers, I know how important international diplomacy is when it comes to tackling existential threats. We need a collective response rooted in the spirit and values of the UN Charter that can put us back on a pathway to peaceful co-existence and sustainable development."

#### Elbegdorj Tsakhia

Former President of Mongolia, member of The Elders, and former Prime Minister



"Dealing with the crisis of climate change requires faith in institutions of multilateral governance and cooperation. The geopolitical fissure opened by the invasion of Ukraine has weakened trust among countries and the global will to cooperate."

#### Sivan Kartha

Senior scientist, Stockholm Environmental Institute, lead author for the UNFCCC Sixth Assessment Report, and member, Science and Security Board



"Devastating events like the COVID-19 pandemic can no longer be considered rare, once-a-century occurrences. However, disease-induced disaster can be avoided if countries around the world cooperate on global health strategies."

#### Suzet McKinney

Principal and Director of Life Sciences, Sterling Bay, and member, Science and Security Board



"Even if nuclear use is avoided in Ukraine, the war has challenged the nuclear order—the system of agreements and understandings that have been constructed over six decades to limit the dangers of nuclear weapons."

#### Steve Fetter

Dean of the Graduate School and Professor of Public Policy, University of Maryland, and member, Science and Security Board

**Months**

**Weeks**

**Days**

**Hours**

**Minutes**

**90 Seconds**



## The 2023 Clock Statement

### It is 90 seconds to midnight

#### A time of unprecedented danger.

This year, the Science and Security Board of the Bulletin of the Atomic Scientists moves the hands of the Domsday 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.

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.

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 Domsday 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 Domsday 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.

# It is 90 seconds to midnight



## 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 of short range. 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 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.

Sailors aboard the USS Nimitz wave at U.S. and Indian aircraft during Malabar, an India-led multinational exercise in the Indian Ocean, Nov. 20, 2020. Credit: Navy Petty Officer 3rd Class Charles DeParlier.



# It is 90 seconds to midnight

## 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 US, 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 water-borne 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.

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.



Oil and gas condensate fields, gas pumping station, Jan 04, 2021. Credit: ChursaeV13

# It is 90 seconds to midnight

## 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 which may be in violation of the Biological Weapons Convention.



Recent events—including especially the Russian invasion of Ukraine and its 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 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.

Prepared Moderna COVID-19 vaccine syringes await utilization at the base gym, Peterson Air Force Base, Colorado, April 11, 2021. Credit: U.S. Air Force, Sgt. Marko Salopek

# It is 90 seconds to midnight

## 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.

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 build-up 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 towards 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.

SpaceX's Falcon 9 rocket launched 60 Starlink satellites to orbit from Space Launch Complex 40 (SLC-40) at Cape Canaveral Air Force Station in Florida.  
Credit: SpaceX



# Sponsors welcome new members

## Hecker succeeds William Perry as chair

The Bulletin has welcomed Siegfried Hecker as chair of its illustrious Board of Sponsors, a group created by Albert Einstein and first led by Robert Oppenheimer. Hecker followed the 19th US Secretary of Defense William Perry in the leadership role. In addition to Hecker, the Sponsors have named new members: **France Córdova**, **Angela Kane**, **Robert Rosner**, and **Adnan Shihab-Eldin**.

Hecker is director emeritus at the Los Alamos National Laboratory where he worked extensively alongside Russian and Chinese counterparts to enhance nuclear safety and security. He served as professor (research) at Stanford's Department of Management Science and Engineering and as a senior fellow at the University's Center of International Security and Cooperation (CISAC), including as its co-director for six years. He currently serves as professor of practice in the Department of Nuclear Engineering at Texas A&M University and as the distinguished professor of practice in the Middlebury Institute of International Studies at Monterey.

Among other awards, Hecker is the recipient of the American Association of Engineering Societies National Engineering Award (2018), Presidential Enrico Fermi Award (2009), and the US Department of Energy's E. O. Lawrence Award (1984). His book, *Hinge Points: An Inside Look at North Korea's Nuclear Program*, written with Elliot Serbin, was published by Stanford University Press in January 2023.

"The topics the Bulletin covers are as relevant now as they were at the time the Board of Sponsors was founded," said Hecker. "I look forward to leading the Board into an era of renewed investment in, and support of, the Bulletin's vital work."

### About the Board of Sponsors and its first Chair, J. Robert Oppenheimer

The Bulletin's Board of Sponsors was established in December 1948 by Albert Einstein, with J. Robert Oppenheimer as its first chair. Members of the Board of Sponsors are recruited by their peers from the world's most accomplished science and security leaders to reinforce the importance of the Bulletin's activities and publications. Over the years, its ranks have included some 40 Nobel laureates.

The Bulletin has applauded the Department of Energy for the December 2022 announcement that it had vacated the 1954 decision to strip Oppenheimer of his security clearance. US Secretary of Energy Jennifer Granholm stated:

"Dr. J. Robert Oppenheimer occupies a central role in our history for leading the nation's atomic efforts during World War II and planting the seeds for the Department of Energy's national laboratories—the crown jewels of the American research and innovation ecosystem.

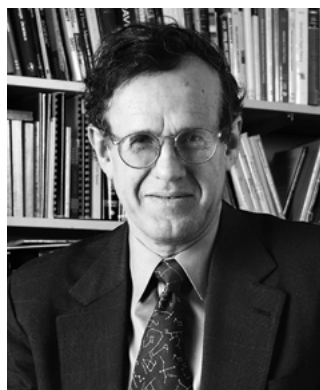
In 1954, the Atomic Energy Commission revoked Dr. Oppenheimer's security clearance through a flawed process that violated the Commission's own regulations. As time has passed, more evidence has come to light of the bias and unfairness of the process that Dr. Oppenheimer was subjected to while the evidence of his loyalty and love of country have only been further affirmed."



**France Córdova** is an astrophysicist and the fourteenth director of the National Science Foundation. Córdova was the first woman to serve as NASA's chief scientist, and she received that organization's Distinguished Service Medal (1996) for her service. She was the first woman and the first minority president of Purdue University and the chancellor of the University of California Riverside, among other distinctions.



**Angela Kane** spent more than 35 years working for the United Nations, serving in senior positions such as Assistant Secretary-General for Political Affairs, Under-Secretary-General for Management, and High Representative for Disarmament. Currently, she teaches at Tsinghua University/Schwarzman Scholars in Beijing and the Paris School of International Affairs (SciencesPo).



**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. He is the former Director of Argonne National Laboratory and from 2013-2021 he chaired the Bulletin's Science and Security Board. In 2023 he began his term as president of the American Physical Society.



**Adnan Shihab-Eldin** is a senior visiting research fellow at Oxford Institute for Energy Studies (UK). He has held academic appointments at Kuwait University, UC Berkeley, Harvard University and CERN, and served as the director general of the Kuwait Foundation for the Advancement of Sciences. Shihab-Eldin has held senior director positions at international organizations such as the International Atomic Energy Agency (IAEA), UN Education, Science and Culture Organization (UNESCO), and the Organization of the Petroleum Exporting Countries (OPEC).

# Science board changes announced

## New experts welcomed

### Science and Security Board

Among its many responsibilities, the Bulletin's Science and Security collaborates with Editor-in-Chief John Mecklin in producing the annual Clock Statement. This year, three new members signed on to the task. The Bulletin extended its gratitude to departing members **Lynn Eden**, **Rodney Ewing**, and **Robert Rosner**, who reached the end of their terms, for their invaluable service over many years.

**Alexander Glaser** is associate professor in the School of Public and International Affairs and in the Department of Mechanical and Aerospace Engineering at Princeton University. He is also a co-director of Princeton's Program on Science and Global Security. Along with Harold Feiveson, Zia Mian, and Frank von Hippel, he is co-author of *Unmaking the Bomb* (MIT Press, 2014). *Foreign Policy* named Glaser one of the 100 Leading Global Thinkers of 2014 for his work on nuclear warhead verification. Along with Tamara Patton and Susanna Pollack, he is an executive producer of the virtual reality documentary "On the Morning You Wake." Glaser holds a PhD in Physics from Darmstadt University and served on the Bulletin's Science and Security Board from 2008-2014. He is a fellow of the American Physical Society.

**David 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. He was an early pioneer in the modern study of the human indigenous microbiota (microbiome), and his current research work focuses on assembly, diversity, stability, and resilience of human microbial communities. Relman served as President of the Infectious Diseases Society of America, is a founding member of the National Science Advisory Board on Biosecurity, and currently serves on the Intelligence Community Studies Board at the U.S. National Academies of Science, Engineering, and Medicine. He is also an incoming member of the Defense Science Board at the U.S. Department of Defense and a member of the National Academy of Medicine.

The board also welcomed **Ambuj Sagar**, who is 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 National Academies of Sciences, Engineering, and Medicine panel that authored the recent report on geoengineering research and governance.



1. Alexander Glaser  
2. David Relman  
3. Ambuj Sagar

# Governing board changes announced

## Members add deep and varied expertise

### Governing Board

The Governing Board welcomed four new members in September 2022: **Bryan Bacon**, **Harold Jones**, **Joanne Po**, and **Dimple Shah**, building the board's financial acumen, understanding of the multimedia landscape, corporate social responsibility expertise, and deep ties to science and engineering.

The Governing Board also said a grateful farewell to Austin Hirsch. The longtime treasurer of the board was named to Crain's Chicago Business 2021 Notable Nonprofit Board Leaders list. The list recognizes 70 nonprofit board leaders who "have advanced the cause of a nonprofit organization and raised its profile in the community."

Hirsch, a partner in Reed Smith's global corporate group, has served on the Bulletin's board since 2010, "working tirelessly behind the scenes to help protect and advance the Bulletin's image and reputation," said President and CEO Rachel Bronson. Reed Smith, Hirsch, and former board member, the late Lowell Sachnoff, were honorees at the Bulletin's 2019 Annual Dinner.

The Bulletin's Governing Board is composed of recognized leaders in their respective fields. Its responsibilities include setting the strategic direction of the organization; ensuring the organization operates in a legal, ethical, and professional manner; participating in Doomsday Clock discussions; representing the organization at public events; and assisting in raising funds for the Bulletin's continued operation and fiscal stability. The Board meets quarterly, and its subcommittees meet more often.



**Bryan Bacon** is a senior vice president and senior portfolio manager at Northern Trust, where he advises high net worth families. He is a past board member of Beyond OCD and a current board member of Synapse House. He holds a Bachelor of Arts degree in economics from Wheaton College and a Master of Business Administration from Northwestern's Kellogg School of Management. He has joined the Board's Finance Committee.



**Harold Jones** is chief sustainability officer and executive vice president, Eaton Business System for Eaton, a global intelligent power management company. He also leads EBS, which enables Eaton to operate its businesses and functions in a common way. He leads the company's Quality and Continuous Improvement functions, Environmental, Health & Safety, Global Security, and co-leads Eaton's Industry 4.0 initiatives. Harold holds PhD, MS, and BS degrees in civil engineering from Marquette University and is a licensed professional engineer. He has joined the Governance Committee.



**Joanne Po** is a media innovator and leader with more than 25 years of television and digital video journalism experience. She is the head of multimedia content and executive producer at CoinDesk, the most trusted and influential media and events platform covering the global emergence of the blockchain, crypto and Web3 economy. Previously, Po was the managing director at Fox News Digital and was *The Wall Street Journal's* executive producer & deputy head of video. Po has joined the Bulletin's Marketing and Communications Committee.



**Dimple Shah** is the President and CEO of Gamma Technologies (GT), a global engineering software company that helps accelerate sustainable innovation with predictive computer and advanced simulation technologies traversing scales and physics. He is passionate about solutions that make our planet more habitable and sustainable for future generations. He holds a BE in Mechanical Engineering from COEP Technological University and a MS in Mechanical Engineering from Stony Brook University. He has joined the Bulletin's Finance Committee.



# Welcoming new colleagues

## 22/23 Editorial Fellows join the Bulletin

The Bulletin welcomed Kimberly Ma and Chad Small to the 2022/23 class of Editorial Fellows. Ma and Small write on biosecurity and climate change, respectively. “Kimberly and Chad bring a wealth of knowledge and unique perspective to the subjects they cover, and we are grateful to provide a platform to uplift their voices,” said Bulletin editor-in-chief John Mecklin.

They join second-year Editorial Fellows Lauren Sukin, who focuses on nuclear risk, and Trenton W. Ford, who covers disruptive technologies.

### About the Editorial Fellows Program

The Editorial Fellows Program rests on the understanding that science is expected to advance more in the next 40 years than in all of human history, raising political and ethical questions whose answers will shape the future safety and security of our planet.

Editorial Fellows have established record of publishing quality work or have been identified as an emerging leaders in their respective fields. Fellows produce a regular column for which they are compensated. The program is a one-year commitment with the opportunity to renew.

The program is part of an organizational commitment to diversity, equity, and inclusion designed to promote a greater variety of viewpoints and lived experiences on the Bulletin's platform.



**Kimberly Ma** is a PhD student in Biodefense at George Mason University and a senior analyst with the Preparedness Division at the Association of State and Territorial Health Officials (ASTHO). Previously, she was a biosecurity project lead with CRDF Global for projects funded by the Department of State's CTR Biosecurity Engagement Program, and she served as team lead for CRDF's Women in Science and Security Initiative. Kimberly focuses on capacity-building in healthcare systems, risk communications, emerging biological threats due to climate change and urbanization, and advancing equity in national security workplaces. She holds a Master of Science from Georgetown University's Biohazardous Threat Agents program and a double bachelor's degree in molecular biology and Japanese from Dartmouth College.



**Chad Small** is a freelance journalist and a PhD student in Atmospheric Sciences at the University of Washington. His research interests focus on the impacts and dynamics of severe precipitation events in a changing climate. Chad's journalist work—frequently centering on environmental justice, science policy, and potential responses to climate change—has been featured in *Grist*, *Next City*, and *Gothamist*. He holds a BS in Environmental Engineering from Yale University and a MS in Earth and Atmospheric Science from the City College of New York. Feel free to follow him on Twitter @SmallThoughts.

### Stanford undergrads weigh in on Doomsday Clock

The Stanford University Ethics Bowl team—formed by five undergraduates and then-captain, Sarah Yribarren, a sophomore studying chemical engineering—recently engaged in a months-long, passionate discussion on the ethical value of the Doomsday Clock.

In a June article titled “Some disagree that it is 100 seconds to midnight. These undergrads held a debate,” Nitish Vaidyanathan, who is a research assistant to Science and Security Board member Scott Sagan at Stanford's Center for International Security and Cooperation (CISAC), described how the team spent many hours deep-diving into the Bulletin's archives. “The argument that Sarah and the team crafted raises important questions worth exposing to the Bulletin's readers as it serves both as a pressure test of and an earnest reaction to the work of the board,” said Vaidyanathan.

### Recent clock changes

2018

2 Minutes

2019

2 Minutes

2020

100 Seconds

2021

100 Seconds

2022

90 Seconds

# Human/Nature

## Bulletin brings exhibition to Chicago venues

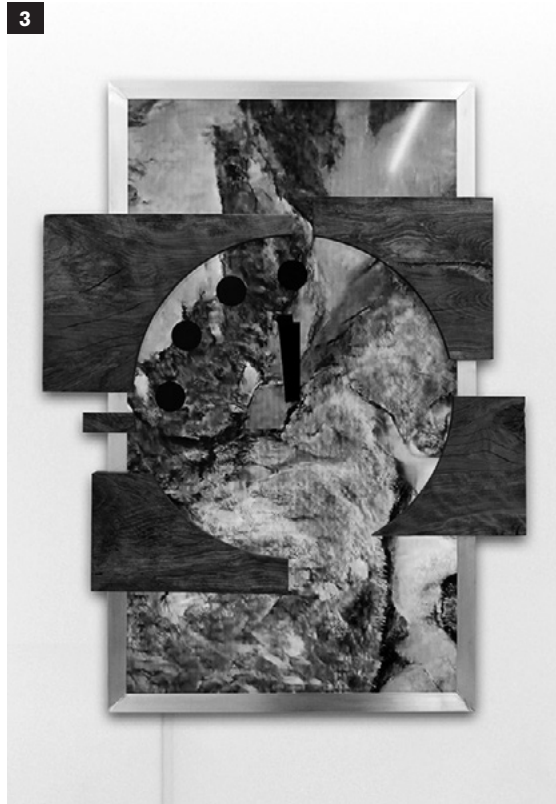
### Weinberg/Newton Gallery opens exhibition

Standing in the middle of the first floor of the Keller Center, home of the University of Chicago's Harris School of Public Policy which houses the Bulletin, is a sweeping, lush sculpture made of bright green moss, pink and white orchids, and black plastic. *Monument*, created by Regan Rosburg, is meant to symbolize regeneration and beauty. It's one of several works in the Human/Nature exhibition that captures the urgency needed to act on climate change and imagines a dystopian world where no action has been taken.

The exhibition first opened in January at Chicago's Weinberg/Newton Gallery, representing a unique partnership between the Bulletin and gallery Executive Director David Weinberg. The Weinberg/Newton Gallery is a non-commercial gallery with a mission to collaborate with nonprofit organizations and artists to educate and engage the public on social justice issues. Climate scientist Katharine Hayhoe spoke at the gallery opening, affirming that scientific data "tells us the planet is warming; the science is clear that humans are responsible; the impacts we're seeing today are already serious; and our future is in our hands."

Human/Nature was guest curated by Cyndi Conn, a member of the Bulletin's Governing Board. It also includes paintings, textiles, and AI-generated videos from international artists including Matthew Ritchie, Laura Ball, Stas Bartnikas, Donovan Quintero, Obvious, and Karen Reimer. Video interviews from climate scientists and experts offer actionable ideas on how to contribute to a sustainable future.

"By working together with leading contemporary artists, designers, and creative communicators, the Bulletin seeks to broaden the conversation, generating innovative ways of framing crucial issues around peace and security," says Rachel Bronson, the Bulletin's president and CEO.



1. Monument, created by Regan Rosburg
2. Everything is Fine, created by Regan Rosburg
3. The DomsdAI Clock, created by Obvious and Stas Bartnikas
4. Katharine Hayhoe, chief scientist of The Nature Conservancy

# Arts Science Initiative

## Doomsday Clock inspires artist

### Confronting disillusion

Collage artist Sam Heydt has released a collection of art inspired by the Doomsday Clock that she titled *100 Seconds to Midnight*.

Bulletin brand manager Sarah Starkey said that Heydt combines images of destruction with portrayals of the virtues born from the American Dream to “confront the disillusionment of our time with the ecological and existential nightmare it is responsible for.”

Heydt grew up watching the Doomsday Clock count down from 17 minutes to 100 seconds to midnight and says it has been instrumental in informing and inspiring her work. “The edge is closer than we think,” she says. “In a time marked by mass extinction, diminishing resources, global pandemic, and climate change, the future isn’t what it used to be.”



**“In a time marked by mass extinction, diminishing resources, global pandemic, and climate change, the future isn’t what it used to be.”**

1. “100 Seconds to Midnight”  
2. “What Else is On”



# Conversations Before Midnight 2022

## Live-streaming attracts more participants

### Ploughshares Fund Emma Belcher keynotes event

The Bulletin welcomed nearly a thousand guests to live-streamed segments of Conversations Before Midnight 2022, its virtual annual gathering on November 9. We exceeded the evening's \$10,000 match challenge by 130%, raising more than \$23,000, in addition to funds contributed to host the event itself.

The keynote speaker for the event was Ploughshares Fund President Emma Belcher, who was interviewed by Bulletin Editor-in-Chief John Mecklin. The Ploughshares Fund is a global security foundation dedicated to reduce the threat of nuclear weapons.

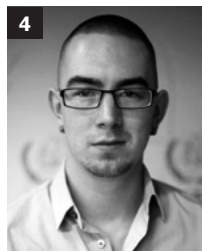
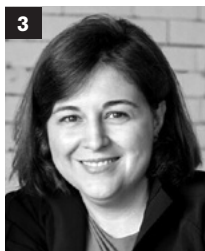
Prior to joining Ploughshares, Belcher spent nearly a decade at the John D. and Catherine T. MacArthur Foundation, where she led the foundation's Nuclear Challenges grantmaking program. She has also served as an advisor in Australia's Department of the Prime Minister and Cabinet on national security and international affairs. Belcher has been on the TED Talks platform twice, discussing the importance of confronting, humanizing, and ultimately solving the existential threat of nuclear weapons.

Referring to the Russian invasion of Ukraine and Vladimir Putin's veiled threats to use nuclear weapons, Belcher said that "the nuclear threat is very dangerous and we've ignored it too long. The status quo that we've been accepting is undermining our security and our sense of humanity. So it's really incumbent on us to act now."

Ukrainian journalist Illia Ponomarenko provided an on-the-ground update on the Russian war against his country, in conversation with Governing Board member Melissa Harris.

2021 Rieser Award recipient Noah Mayhew gave remarks describing the thinking behind his award winning essay published by the Bulletin, titled "ICBMs are ridiculous."

Some 200 guests and experts also engaged in small-group discussions on topics of nuclear risk, climate change, disruptive technologies, and biosecurity.



1. Emma Belcher
2. Illia Ponomarenko
3. Melissa Harris
4. Noah Mayhew
5. Invitation to event, Credit: Evan Hatch

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**"...the nuclear threat is very dangerous, and we've ignored it too long. The status quo that we've been accepting is undermining our security and our sense of humanity."**

## In memoriam

### Legacies of leadership



#### Madeleine Albright

Madeleine Albright's engagements with the Bulletin were brief but highly effective. The former US Secretary of State under President Clinton and the first woman to ever hold the position, who also served in the National Security Council and as the United States' Permanent Representative to the United Nations, invited readers to attend our 2020 annual gathering, drawing in new participants.

In 2018, Bulletin CEO and President Rachel Bronson interviewed Albright at the University of Chicago's Institute of Politics about Albright's prescient book, *Fascism: A Warning*, which examines fascism in the twentieth century and its legacy in today's world. Bronson noted Albright's devotion to reducing the nuclear threat to civilization.

In a tribute published by the Bulletin in March, Melanne Verveer, executive director of the Georgetown Institute for Women, Peace and Security, said that Albright was a powerful voice for the United States on international affairs and a global force for good.



#### Mikhail Gorbachev

With the passing of Mikhail Gorbachev in August, an era characterized by change and reduced international tensions—from the reform and openness promised by perestroika and glasnost to the dissolution of the Soviet Union and the end of the Cold War—seems to have reached an end, said Editor-in-Chief John Mecklin.

In 2009, Gorbachev wrote an article for the Bulletin with Rogelio Pfitter on disarmament lessons from the Chemical Weapons Convention. The last general secretary of the Soviet Communist Party and the first (and only) president of the Soviet Union, Gorbachev was admired in the West for initiatives that led to significant reductions in US and Soviet nuclear arsenals, and to what seemed a greatly reduced likelihood of nuclear war.

The former Soviet leader also introduced then Board of Sponsors Chair William Perry, the 19<sup>th</sup> US Secretary of Defense, and Bulletin President and CEO Rachel Bronson at a conference in Japan in 2020, recognizing the 75<sup>th</sup> anniversary of the US bombing of Hiroshima and Nagasaki. Gorbachev noted the Bulletin's role in providing accurate reports on nuclear arsenals and diplomacy.



#### Mike Moore

Mike Moore served as editor-in-chief of the Bulletin as the Soviet Union dissolved and new, post-Cold-War arms control challenges began to emerge. He died in October.

In 1991, Moore saw the Bulletin's Doomsday Clock move to its farthest point from metaphorical midnight ever, 17 minutes, as the magazine sought to "to memorialize the death of the East-West nuclear arms race and the apparent birth of democracy in Russia." That year's high hopes for a new era free from nuclear crises and other dangerous geopolitical machinations proved short-lived, however, and the Clock ticked steadily closer to midnight over most of Moore's tenure from 1990 to 2000.

Pointing to global conflict and the social and economic chaos that was engulfing post-Soviet Russia, Moore reminded readers in 1995, when the clock moved to 14 minutes to midnight that, "When the Cold War ended, nuclear weapons didn't go to the shredder, like so many worn-out cars. They are still with us, and we must not forget that."



#### Ben Mottelson

Board of Sponsors member Ben Roy Mottelson, an American-Danish theoretical physicist who shared a Nobel Prize for revealing how the motion of protons and neutrons could distort the shape of the nuclei of atoms, died in May. He was 95, according to an obituary published by *The New York Times* on May 19.

Mottelson was awarded the Nobel in physics in 1975 along with James Rainwater, a Columbia University physicist, and Aage Bohr, a Danish scientist whose father, Niels Bohr, had been awarded the Nobel in physics in 1922.

Mottelson was born in 1926 in Chicago. After graduating with a bachelor's degree from Purdue University in 1947, he entered Harvard for postgraduate studies in nuclear physics. With Julian Schwinger, a Nobelist in 1965, as his thesis adviser, Mottelson obtained his Ph.D. in 1950. He had successive appointments in Copenhagen, the last as a professor at the Nordic Institute for Theoretical Atomic Physics, which was founded there in 1957. He remained in Denmark for the rest of his professional life.

# Philanthropy

## The impact of values-driven giving

### Bob and Ellie Meyers

Einstein Circle donors Bob and Ellie Meyers have been Bulletin supporters for more than 25 years. They regularly attend the Bulletin's signature virtual event, "Conversations before Midnight," gathering three generations of the Meyers family for an expert-lead family discussion on the most crucial topics facing humanity.

Bob was initially drawn to the Bulletin because of his interest in the reduction of nuclear threats and the potential for accidents. As a US Air Force captain and physician in the medical corps stationed in Colorado Springs at NORAD, Bob first recognized the potential of accidents—basically the nuclear arms policy of "launch on warning."

On his first night on call at the USAF medical dispensary at NORAD, he was invited to have a midnight sandwich in the facility next door. The facility happened to be the NORAD command center, the location from which retaliation with nuclear missiles to the threat of a Soviet attack would be ordered.

That night while observing the command center, he asked the question "What happens if there is a mistaken retaliation?" "It's all over," he was told.

What drives Bob's activism is his understanding of "accident theory," which is a recognition that accidents are normal and it is expected that accidents will occur in complex, tightly coupled systems. This makes preparedness and contingency plans urgent matters, if not a moral responsibility.

Over time, his growing concern about nuclear miscalculations led to a deep friendship with the late Bruce Blair, an expert on "launch on warning," a former nuclear launch officer, and recipient of the MacArthur genius award. Bruce was also the founder of the nuclear group Global Zero.

Bob's interest in accident theory also motivated him to become involved in potential bioterror risks such as using smallpox as a weapon. He helped to lead efforts to prepare Chicago area hospitals for unexpected biological catastrophic events. With other otolaryngologists, he has investigated the origin of infection of Covid via the nose, and the potential of eliminating the virus within the nose using various virucidal non-toxic agents, thus preventing infection.

The Meyers are also helping to underwrite the Bulletin's biorisk initiative to map high-containmentment laboratories around the world in partnership with faculty members at Kings College London and George Mason University in Virginia.

The possible laboratory origin of the Covid pandemic is a serious contemporary catastrophe in which accident theory may play a part.

One accident is intolerable, whether biologic or nuclear.

The Meyers' steady generosity enables the Bulletin to publish advanced research to reduce nuclear risk, advance climate solutions, and govern disruptive technologies. They also invite others to join the Bulletin community of donors.

"The Meyers regularly and repeatedly help the Bulletin deliver on our mission," said Rachel Bronson, the Bulletin's president and CEO. "We are thankful for their vision and thoughtful philanthropy."

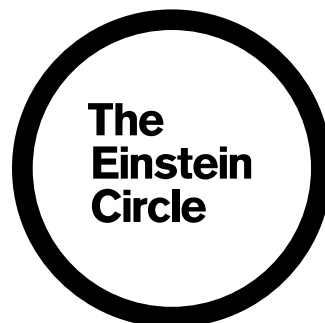


### The Legacy Society

Our Legacy Society was created to recognize and honor friends who have provided for the Bulletin's future through their estate plans. By including the Bulletin in your will or trust, or by naming the organization as a beneficiary of a life insurance policy, IRA or other financial vehicle, you can make a significant gift that costs you nothing during your lifetime.

Chief Advancement Officer Colleen McElligott said that Legacy Society donors provide for the Bulletin because they have confidence and trust in the organization to continue to open channels between science and public policy leaders to make the world a safer place.

"I always encourage prospective legacy donors to consult with their financial advisors for the expert advice that will guarantee their peace of mind. We are deeply grateful for their trust and convictions," she said.



### Einstein Circle

The Bulletin recognizes annual leadership gifts of \$1000 or more with membership in the Einstein Circle, which honors those people who consistently contribute at high levels. "Every year these loyal donors demonstrate their dedication to our publishing and outreach programs to communicate facts, evidence-based research, and rational assessments about the most pressing challenges facing our planet," said McElligott.

The number of donors at the \$1000 and up level has grown by 45 percent over the past 5 years, according to McElligott. "We are mindful of the responsibility we have to continue to publish the caliber of content our donors expect. They have allowed the Bulletin to continue to grow carefully over more than 75 years."

Einstein Circle members receive access to special briefings, exclusive invitations, and personalized communications on issues.

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**For more than seven decades, a dedicated network of board members, advisors, foundations, and donors have sustained the Bulletin of the Atomic Scientists.**

**We extend our deepest gratitude to the board leaders, individuals, and institutions who made contributions between January 1 and December 31, 2022. Their names are listed here, with our sincere thanks for making everything we do possible.**

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# Financial Overview

## Management Discussion and Analysis

This Management Discussion and Analysis (MD&A) aims to help readers of our financial statements make reasonable inferences about the Bulletin's progress in accomplishing our mission in a financially responsible way. This narrative supplements the financial statements on pages 40 and 41. To improve financial reporting to match the flow of our operations, the Bulletin converted its fiscal year to end on June 30th, beginning in 2021. As regular readers of our annual reports will recall, we foreshadowed this change in the 2020 annual report, and acknowledged the change in our 2021 annual report. Note that financial information for 2021 represents a six-month "stub" period as part of this transition.

Individuals and foundations continued to fuel the Bulletin's mission-critical work in 2022. We present examples of this throughout the pages of this annual report. I am pleased to share those contributions to the Bulletin grew by over 60% in 2022 from the comparable period from the prior year, which provided over two million dollars to support our work. The chart on page 41 labeled "New Individual Gifts and Corporate Support 2018-2022" shows the growth in our support over time. The spike in 2022 includes significant contributions from the MacArthur and Carnegie Foundations, as well as several individuals supporting our work on bio-risk and more general capacity building. There was a corresponding expense increase of just under \$400K as the Bulletin has continued to make substantial investments in human capital, programmatic activities, and infrastructure. Careful monitoring of all costs and sound budgeting practices allowed the Bulletin to have a net increase of revenues over expenditures of just over \$5K.

The long-term impact of the COVID-19 pandemic on the Bulletin's investments, donors, and operations remains uncertain. The Bulletin suspended some programs and in-person events in the past three years considering the restrictions the pandemic presented. Many of these programs and events moved to a virtual environment, with some returning to in-person as conditions allowed. The Bulletin continues to communicate with our stakeholders and closely monitor our investment portfolio and its liquidity, which remains strong.

The Bulletin was also fortunate to have the support of multi-year grants from several major foundations renewed in 2022, along with multi-year individual commitments. Generally Accepted Accounting Principles (GAAP) requirements continue to make the annual presentation challenging. GAAP requires us — like our counterparts — to recognize these multi-year gifts when pledged. This recognition occurs even when funds may not be received or used until later years of the grant's disbursement. The deferral of such revenue for future operations occurs before the calculation of net revenue for the year.

The chart of "Foundation Support 2018-2022" on the next page shows the cyclical nature of these contributions and how we manage it. Our ability to secure multi-year support is a strong endorsement of our efforts, notwithstanding the required accounting treatment. In making multi-year commitments, our supporters are providing external validation of our strategy, governance, and impact.

Readers will notice a significant increase in assets in 2022. As noted above, the Bulletin temporarily restricts assets to support multiple years of operations and specific initiatives, such as support

raised in 2022 for a major conference the Bulletin is hosting in Geneva in 2023. The Bulletin invests in a conservative portfolio of assets spread among numerous classes of investments. Such amounts are released from restriction into normal operations to meet requirements. In addition to temporarily restricting contributions for future periods and initiatives, the Bulletin uses surpluses of unrestricted net assets to support future operations when results end positively. As previously mentioned, the Bulletin ended 2022 with a small operating surplus that was added to our unrestricted net assets at the end of the year and is available for use in 2023. As in the past, the Bulletin continues to have no long-term debt.

We design our financial reporting to provide donors and the public with a transparent overview of our finances, which Miller Cooper LLP audits. As in prior years, Miller Cooper LLP provided the Bulletin with an "unmodified" opinion, which is the highest level of assurance given. The complete audited financial statements for 2022 are available by request or on GuideStar. If you have any questions about this report or need additional financial information, please do not hesitate to contact the Bulletin at [finance@thebulletin.org](mailto:finance@thebulletin.org).

Thank you for your generous and sustained support. We could not do this without you.

Sincerely,



Rachel Bronson, PhD  
President and CEO



# Financial Overview

## Charts and Statements

### STATEMENT OF ACTIVITIES

For the year ended June 30, 2022

Revenue and other support	2022
Magazine	279,391
Individual gifts and corporate support	1,294,077
Foundation grants	1,628,802
Other revenue	(22,236)
In-kind*	726,669
<b>Total revenues and gains without donor restrictions</b>	<b>3,906,703</b>
Revenue released from restrictions	240,395
<b>Total revenues, gains and support without donor restrictions</b>	<b>4,147,098</b>
<b>Operating Expenses by Function</b>	
Publication and website program	2,337,743
Fundraising	201,299
Management and general	162,088
In-Kind*	726,669
<b>Total operating expenses</b>	<b>3,427,799</b>
<b>Net Income</b>	<b>719,299</b>
<b>Board designated transfer (transfer into reserves)/ utilization of reserves</b>	<b>(713,697)</b>
<b>Net Income from Ordinary Operations</b>	<b>5,602</b>

### STATEMENT OF FINANCIAL POSITION

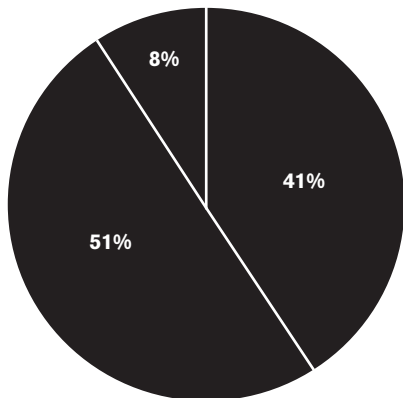
For the year ended June 30, 2022

Assets	2022
Cash and investments	3,369,734
Accounts receivable, net of allowance	55,816
Pledges receivable	795,512
Prepaid expenses	33,201
<b>Total current assets</b>	<b>4,254,263</b>
Pledges receivable, less current portion	500,000
Property and equipment, net	26,836
Website improvements, net	28,236
<b>Total noncurrent assets</b>	<b>555,072</b>
<b>Total assets</b>	<b>4,809,335</b>
<b>Liabilities and Net Assets</b>	
Accounts payable and accrued expenses	177,184
Deferred subscription revenue	20,408
Retirement payable	-
<b>Total liabilities</b>	<b>197,592</b>
<b>Net Assets</b>	
Without donor restrictions	1,794,216
With donor restrictions	2,817,527
<b>Total net assets</b>	<b>4,611,743</b>
<b>Total liabilities and net assets</b>	<b>4,809,335</b>
<b>Change in Unrestricted Net Assets</b>	
Net assets, beginning of the year	1,074,917
Revenues with donor restrictions	713,697
Net Income	5,602
<b>Net assets, end of the year</b>	<b>1,794,216</b>

\*In-Kind is further categorized as follows: \$615,367 for writers contributions to our publications, \$111,302 for professional services

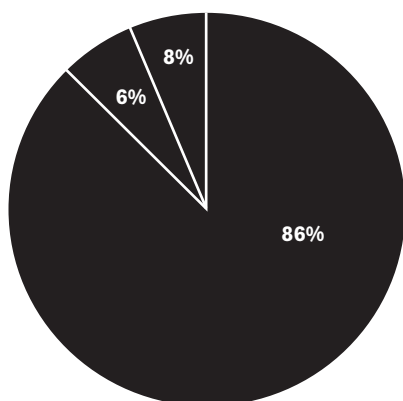
# Financial Overview

## Charts and Statements



### OPERATING REVENUE

Donor support*	1,294,077	41%
Foundation grants*	1,628,802	51%
Earned revenue	257,155	8%
*After restriction adjustments	3,180,034	

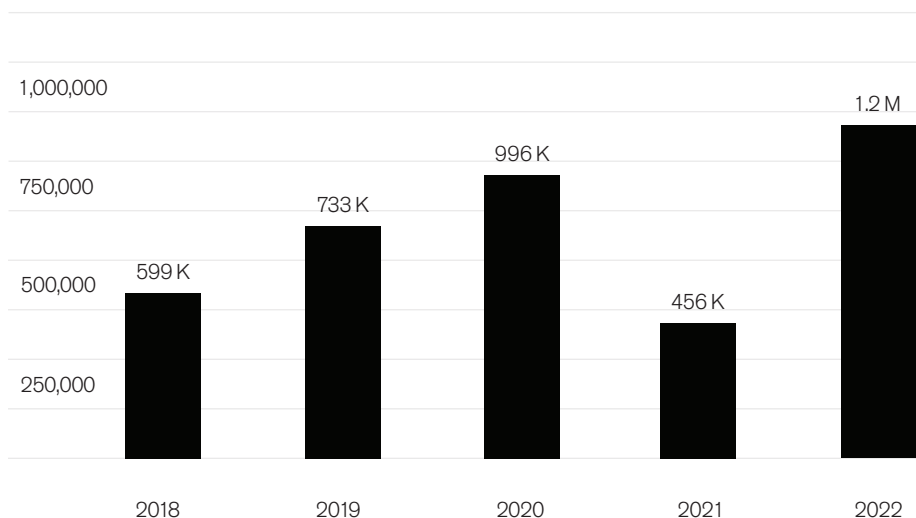


### OPERATING EXPENSES

Program	2,953,110	86%
Fundraising	201,299	6%
Management and general	273,390	8%
*After restriction adjustments	3,427,799	

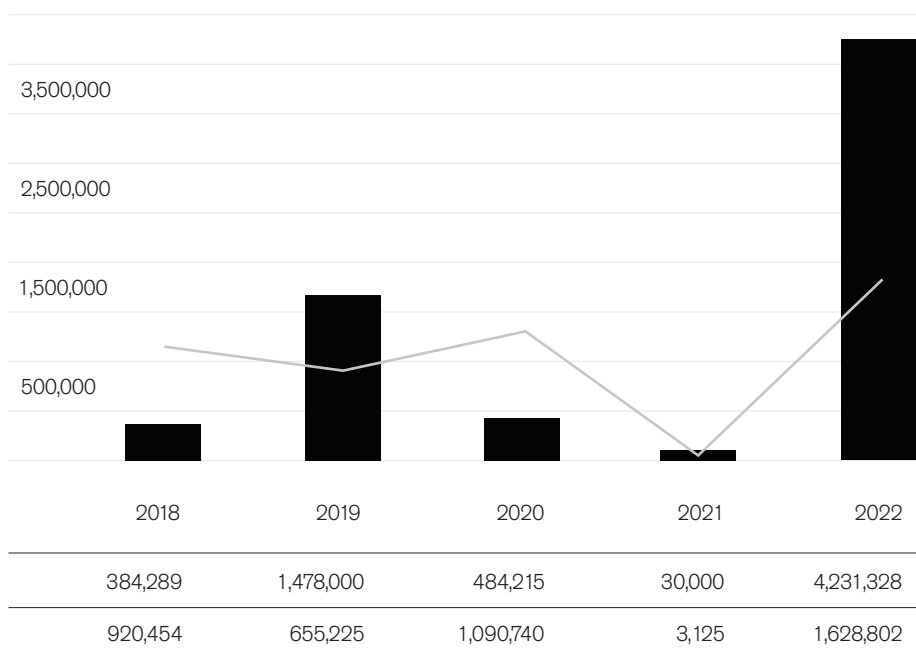
### NEW INDIVIDUAL GIFTS AND CORPORATE SUPPORT

2018 – 2022



### FOUNDATION SUPPORT

2018 – 2022



- Foundation Grants New
- Foundation Grants After Restriction Adjustments

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Sarah Starkey, Brand Manager

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Erik English, Associate Multimedia Editor

Matthew Field, Biosecurity Editor

Thomas Gaulkin, Multimedia Editor

Sara Goudarzi, Associate Editor

Jessica McKenzie, Associate Editor

Dawn Stover, Contributing Editor

## Finance

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Christine Grobart, Account Supervisor

Deisy Hernandez, Bookkeeper

Kennette Benedict, Senior Advisor

Stephen Schwartz, Nonresident Fellow

## Annual Report Design


Pentagram

## Production Management

Kendal Gladish



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