IT IS 5 MINUTES TO MIDNIGHT

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Feature

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Out of the nuclear shadow: Scientists and the struggle against the Bomb

Zia Mian

Abstract

In this essay, adapted from his 2014 Linus Pauling Legacy Award Lecture, Zia Mian, from Princeton University's Program on Science and Global Security, argues that the ideas Nobel laureate Linus Pauling and other scientists struggled hard over the decades to teach the world have now become widely accepted: The world understands the danger of nuclear weapons. But in the essay, Mian argues that absent an aroused and insistent public demanding an end to nuclear weapons, which the early scientists believed was necessary to curb the nuclear danger, the prospects for nuclear disarmament in the foreseeable future appear grim. He concludes: "This is where the scientist has to step aside and the citizen has to step forward."

Keywords

Albert Einstein, Cold War history, Emergency Committee of Atomic Scientists, Eugene Rabinowitch, Franck Report, Frank von Hippel, International Panel on Fissile Materials, Leo Szilard, Linus Pauling, Pugwash

This past year marked the 20th anniversary of the death of Linus Pauling, a Nobel Prize-winning American scientist and a key figure in the global movement to abolish nuclear weapons. The history of this movement, and Pauling's role in it, is documented in the remarkable three-volume series *The Struggle against the Bomb* (Wittner, 1993, 1997, 2003).

One of the most well-known photographs of Pauling shows him in his shirtsleeves, carrying a banner as part of a mass protest at the White House. The photo is from April 28, 1962 and was part of a campaign against the resumption of atmospheric nuclear weapons testing.

Pauling protested on the following day also, and then went in to the White House state dinner for 49 Nobel Prize winners to which he had been invited by President John F. Kennedy. Pauling, who had won the 1954 Nobel Prize for Chemistry, may have been the only one of the 49 Nobel Prize winners who was in the protest.

Eighteen months later, Kennedy signed the Limited Test Ban Treaty, and Pauling subsequently received the Nobel Peace Prize in 1963 for his contribution to achieving the treaty. It made Pauling the only person to win two undivided Nobel Prizes.

Everyone who does so has his or her reasons for joining the struggle against the Bomb. Twenty years after his Nobel Peace Prize, Pauling explained why he had spent so many years writing, speaking out, organizing scientists around the world to sign public petitions, and joining in protests:

> All human beings, all citizens, have a responsibility for doing their part in the democratic process. But almost every issue has some scientific aspect to it, and this one of nuclear war, or war in general, is of course very much a matter of science. (Kreisler, 1983: 7)

This meant, as Pauling put it, "that scientists have a special responsibility."

The future in their bones

The scientist has "the future in their bones," declared the British chemist and writer C. P. Snow in his 1959 lecture at Cambridge University "The Two Cultures" (Snow, 1959). If this is true, then the fear of nuclear weapons has been in the bones of scientists for over a hundred years.

Soon after Henri Becquerel discovered radioactivity in 1896, Marie and Pierre Curie found that it was a property of the uranium atom and possibly other atoms. Then, in 1901, Frederick Soddy and Ernest Rutherford showed that radioactivity was part of the process by which atoms changed from one kind to another and involved the release of energy. It was not long until Soddy and other scientists began to suggest atomic energy could be used to make fearsome weapons.

In 1903, less than a decade after Becquerel's discovery, Soddy warned: "The man who put his hand on the lever by which a parsimonious nature regulates so jealously the output of this store of [atomic] energy would possess a weapon by which he could destroy the Earth if he chose" (Soddy, 1904: 251–252).

It took 30 years before someone worked out the nature of the lever that Soddy had imagined could control the release of atomic energy. It was Leo Szilard, a Hungarian Jewish physicist who studied in Germany and ended up as a refugee in the United States, living for some time in Princeton. Szilard's life has been chronicled in *Genius in the Shadows* (Lanouette, 1992).

In 1933, while crossing the street in London, Szilard came up with the idea of a nuclear chain reaction that in his words could "liberate energy on an industrial scale, and construct atomic bombs" (Rhodes, 1986: 28). The idea was simple. He imagined an atom undergoing a nuclear reaction that produced neutrons and that these neutrons would in turn induce other similar atoms to undergo the same reaction and produce another set of neutrons and so cause a cascade of such reactions.

Understanding the potentially terrible implications of his discovery, Szilard tried to keep it a secret. He also knew it was only a matter of time until other atomic scientists discovered the idea. In 1936, he suggested the need for "a conspiracy of those scientists who work in this field" (Wittner, 1993: 6).

Szilard tried to convince other key scientists who were working on the problem to not publish their work in scientific journals. In his letters to them, he warned that if there was progress on the discovery of a nuclear chain reaction and this work became public, "this might then lead to the construction of bombs which would be extremely dangerous in general and particularly in the hands of certain governments" (Lanouette, 1992: 182).

But other physicists did not agree. In March and April 1939 papers were published showing that when a neutron caused the fission of a nucleus of uranium, along with releasing energy it created more neutrons which could in principle then cause other nuclei of uranium to fission, producing a runaway nuclear chain reaction.

Szilard later reflected that there was "very little doubt in my mind that the world was headed for grief" (Wittner, 1993: 7).

Sleepless nights

When Szilard had worried in the late 1930s about the construction of nuclear weapons, he had in mind the Nazis in Germany. In March 1939, the German armies invaded Czechoslovakia and the world plunged into war.

By 1940, physicists were starting to understand what might be involved in building a nuclear weapon, and what the effects of such a weapon might be. Working together in England, two German physicists, Otto Frisch and Rudolf Peierls, wrote a memorandum to the British government called, ominously, "On the Construction of a 'Super-bomb'" (Frisch and Peierls, 1940).

In this memo, they described the basic principle of building a simple nuclear weapon from uranium. They argued that it was quite conceivable that Germany was developing such a weapon and proposed to the British government that "the most effective reply would be a counter-threat with a similar bomb."

In their memo, Frisch and Peierls imagined what an atomic bomb could do: "The blast from such an explosion would destroy life in a wide area. The size of this area is difficult to estimate, but it will probably cover the center of a big city."

They also pointed out that:

> some part of the energy set free by the bomb goes to produce radioactive substances, and these will emit very powerful and dangerous radiations . . . Even for days after the explosion any person entering the affected area will be killed. Some of this radioactivity will be carried along with the wind and will spread the contamination; several miles downwind this may kill people. (Frisch and Peierls, 1940)

Finally, they explained in their memo that "owing to the spread of radioactive substances with the wind, the bomb could probably not be used without killing large numbers of civilians, and this may make it unsuitable as a weapon for use by this country."

It was a stunningly accurate analysis of the physical effects of a nuclear weapon. The scientists also pointed out the core moral and political challenge of building a bomb with such large-scale and indiscriminate effects. It was a harrowing insight. And the whole thing was kept secret from the public.

The Frisch-Peierls memo of 1940 led to the establishment of Britain's nuclear weapons program. Among the people involved in the program was James Chadwick, the discoverer of the neutron, the particle that makes the nuclear chain reaction possible.

Many years later, Chadwick recalled what happened in the spring of 1941 when he realized that a nuclear weapon was a real possibility. He told an interviewer:

> I remember . . . to this day . . . I had many sleepless nights . . . And I had then to start taking sleeping pills. It was the only remedy. I've never stopped since then. It's 28 years, and I don't think I've missed a single night in all those 28 years. (Weiner, 1969)

Britain did not have the resources to carry the atomic bomb program forward, so it reached out to the United States. Soon the Manhattan Project, a vast secret scientific, technological, military, and bureaucratic complex emerged. A total of 600,000 people worked on the bomb project, with as many as 160,000 active at one time. There were mines, laboratories, and factories in 39 American states, and related facilities in Canada and Africa. It was so secret Congress did not know about it.

As work on the Bomb progressed, leading scientists continued to warn policy makers at the highest levels of the coming danger. After a tour of the Manhattan Project in 1944, the great Danish physicist Niels Bohr, who had shaped our modern understanding of the atom, warned President Franklin D. Roosevelt of the long-term dangers of nuclear weapons.

Bohr advised Roosevelt that "any temporary advantage [that may come because of having nuclear weapons], however great, may be outweighed by a perpetual menace to human security" (Bohr, 1944: 106). Again, the private advice was ignored.

The scientists tried again in June 1945, a month before the first nuclear weapon was tested. Led by Nobel laureate James Franck, a group based in Chicago that included Szilard explained the nuclear dilemma in a secret memo to the US secretary of war. The memo known as the Franck Report begins:

> The scientists on this project do not presume to speak authoritatively on problems of national and international policy. However, we found ourselves, by the force of events, the last five years in the position of a small group of citizens cognizant of a grave danger for the safety of this country as well as for the future of all the other nations, of which the rest of mankind is unaware. We therefore felt it our duty to urge that the political problems, arising from the mastering of atomic power, be recognized in all their gravity, and that appropriate steps be taken for their study and the preparation of necessary decisions. (Franck et al., 1945)

The scientists observed:

> [I]n the past, science has often been able to provide adequate protection against new weapons it has given into the hands of an aggressor, but it cannot promise such efficient protection against the destructive use of nuclear power. This protection can only come from the political organization of the world . . . In the absence of an international authority which would make all resort to force in international conflicts impossible, nations could still be diverted from a path which must lead to total mutual destruction, by a specific international agreement barring a nuclear armaments race.

The scientists' words fell on deaf ears. Many years later, Eugene Rabinowitch, one of the signatories to the Franck Report, regretted not having gone public with the scientists' concern.

In 1971, in a letter to *The New York Times*, Rabinowitch wrote:

> Before the atom bomb-drops on Hiroshima and Nagasaki, I had spent sleepless nights thinking that I should reveal to the American people, perhaps through a reputable news organ, the fateful act—the first introduction of atomic weapons—which the US Government planned to carry out without consultation with its people. Twenty-five years later, I feel I would have been right if I had done so. (Rabinowitch, 1971)

The trigger for Rabinowitch's letter was the leaking of the Pentagon Papers on the Vietnam War by Daniel Ellsberg.

The most gloomy

There was good reason for Rabinowitch's regrets. In his first official statement after the atomic bombing of Hiroshima, President Harry Truman claimed the new weapon as a military breakthrough, a scientific marvel, and a uniquely American achievement. And, despite the warnings of the Chicago scientists, the White House declared the Bomb to be an American secret.

In 1946, Szilard joined with Pauling, Albert Einstein, and others to create an Emergency Committee of Atomic Scientists to educate the public about the dangers of nuclear weapons and the coming nuclear arms race. (Key papers of the Emergency Committee of Atomic Scientists are available at the Oregon State University Libraries' Special Collections & Archives Research Center and some are online at its web page "Dear Professor Einstein: The Emergency Committee of Atomic Scientists in Post-War America.")

On January 22, 1947, they issued a famous letter. It can be seen as marking the end of one era and the start of another in the relationship between scientists, governments, and people on the issue of nuclear weapons. The letter has become a manifesto of sorts for the generations of scientists who have struggled against the Bomb. The letter is very short. It says, in part:

> Through the release of atomic energy, our generation has brought into the world the most revolutionary force since prehistoric man's discovery of fire. This basic power of the universe cannot be fitted into the outmoded concept of narrow nationalisms. For there is no secret and there is no defense; there is no possibility of control except through the aroused understanding and insistence of the peoples of the world.
>
> We scientists recognize our inescapable responsibility to carry to our fellow citizens an understanding of the simple facts of atomic energy and its implications for society. In this lies our only security and our only hope—we believe that an informed citizenry will act for life and not for death. (Einstein, 1946)

Put simply, for the scientists only an informed and active democracy could save humanity from nuclear disaster. The scientists sought both to educate their fellow citizens of the nuclear dangers and at the same time took action themselves as citizens in their own right.

There was reason to be hopeful. The United Nations had just been established with the express purpose, according to the charter, being "to save succeeding generations from the scourge of war" (United Nations, 1945).

The UN Charter explicitly called upon all its member states to "refrain in their international relations from the threat or use of force" against each other.

The very first resolution of the United Nations General Assembly, Resolution 1.1., passed in January 1946, established a commission to draw up a plan "for the elimination from national armaments of atomic weapons."

This was the vision outlined by James Franck, Leo Szilard, and the other Chicago scientists who supported an international authority that would end the resort to force by states and ban nuclear weapons.

But the United States was not willing to give up its monopoly on nuclear weapons, and the Soviet Union was not willing to give up its right to make such weapons as long as the US had them. Instead of the United Nations having control of nuclear technology, the world was to be shaped by the Cold War and the nuclear arms race.

It did not take long before the Soviet Union caught up with the United States. In August 1949, the Soviet Union detonated its first atomic bomb. There was a secret debate within the US government about what should be the appropriate response to the Soviet atomic bomb test, in particular whether the United States should pursue the development of an even more powerful bomb, a hydrogen bomb based on thermonuclear fusion.

The US government committee that was set up to consider the possibility of a hydrogen bomb included some of the scientists who had built the first atomic bomb, among them Robert Oppenheimer, the Italian physicist Enrico Fermi, and Polish scientist I. I. Rabi. The discussions were highly secret.

The committee concluded that the hydrogen bomb could probably be built within five years, but advised against it. The committee argued that "it is clear that the use of this weapon would bring about the destruction of innumerable human lives . . . Its use therefore carries much further than the atomic bomb itself the policy of exterminating civilian populations" (General Advisory Committee, 1949: 158).

The majority view of the committee was that the use of the hydrogen bomb "would involve a decision to slaughter a vast number of civilians." This kind of bomb could become a "weapon of genocide," they warned (p. 160).

The minority view on the committee was that this statement did not go far enough. They argued, "The fact that no limits exist to the destructiveness of this weapon makes its very existence and the knowledge of its construction a danger to humanity as a whole. It is necessarily an evil thing considered in any light" (p. 161).

This last great effort by the atomic scientists to try and shape government policy from the inside and so limit the danger to humanity failed. The committee's findings were ignored. The United States launched an urgent program to build the hydrogen bomb. The report itself was kept secret. It was not declassified until 1974.

The world soon came to know of the dangers of the hydrogen bomb, despite the secrecy. In March 1954, the United States carried out the Bravo thermonuclear test at Bikini Atoll in the Pacific. It had an explosive power equivalent to 15 million tons of TNT, a thousand times bigger than the Hiroshima bomb.

The explosion produced radioactive fallout that traveled a hundred miles. It affected hundreds of inhabitants of the Marshall Islands and the crew of the Japanese fishing boat Lucky Dragon. One of the crew later died from radiation poisoning.

It was against this background that in July 1955, Einstein, Pauling, Joseph Rotblat (who received the Linus Pauling Legacy Award in 2003), and other scientists founded the Pugwash movement.

The founding declaration of Pugwash, known as the Russell-Einstein Manifesto, showed that the scientists were more troubled than ever. The declaration observed that:

> the general public, and even many men in position of authority, have not realized what would be involved in a war with nuclear bombs . . . The best authorities are unanimous in saying that a war with H-bombs might quite possibly put an end to the human race . . . We have found that the men who know most are the most gloomy. (Butcher, 2005: 25–26)

The scientists may have been gloomy but they were not dismayed. They were soon at the forefront of the campaign against nuclear weapon testing and in efforts to restrain the nuclear arms race. These efforts had big ups and downs, but when the efforts of the scientists merged with and supported large public anti-nuclear peace movements there was some success.

Even leading insider scientists eventually understood the need for a peace movement and public participation. The most interesting example perhaps was George Kistiakowsky, the senior Manhattan Project scientist who served as science advisor to President Eisenhower and advised several subsequent administrations.

In the early 1980s, reflecting back on his years of service as a scientific insider and advisor, Kistiakowsky wrote: "Forget the [inside] channels. There simply is not enough time left before the world explodes. Concentrate instead on organizing, with so many others who are of like mind, a mass movement for peace such as there has not been before" (Kistiakowsky, 1982: 3).

The last such mass movement that worked in alliance with the scientists was in the 1980s. It brought together the Nuclear Freeze movement in the United States with the nuclear disarmament movements in Western Europe and scientists in the West and in the Soviet Union. The millions of people who took to the streets were an amazing demonstration of what the scientists had hoped for: the "aroused understanding and insistence of the peoples of the world," pushing back against the nuclear danger.

One result of this movement was the 1986 summit in Reykjavik between Ronald Reagan and Mikhail Gorbachev. The leaders of the two superpowers agreed in effect to end the arms race and shared a vision of a world free of nuclear weapons. It marked the beginning of the end of the Cold War.

Prospects

Where are we now, some 30 years later? Sadly, there are reasons to be gloomy.

The Cold War came and went. The number of nuclear weapons has fallen dramatically. But the Bomb has remained.

The 1996 Comprehensive Test Ban Treaty bans all nuclear weapons testing. But the United States has signed but not ratified this treaty. The US nuclear weapons test site at Nevada is kept ready to resume testing. Russia has signed and ratified the treaty, as have Britain and France, but China has signed but not ratified and says it will only do so once the United States ratifies. Apart from the United States and China, the other key nuclear weapon state holdouts are India, Pakistan, Israel, and North Korea.

There has also been limited progress in ending the production of plutonium and highly enriched uranium for nuclear weapons. These are the materials that undergo the chain reaction and make nuclear weapons possible. The good news is that most of the nuclear weapon states have ended their production of these materials for weapons purposes. Today, only India, Pakistan, Israel, and North Korea are still producing these fissile materials for weapons.

But it has now been 20 years since the United Nations General Assembly mandated negotiations on an international treaty to ban the production of fissile materials for nuclear weapons. Efforts to start these talks have stalled. For the last decade in particular, the obstacle to beginning the talks has been Pakistan. But this obstruction has been possible only because the United States has decided that the most important issue in dealing with Pakistan is the war against the Taliban and Al Qaeda.

The situation is not hopeless. The International Panel on Fissile Materials, of which I am a member, was founded in 2006. It brings together scientists, policy experts, and former diplomats from 18 countries to provide and support the technical basis for policy initiatives to reduce global stockpiles of highly enriched uranium and plutonium.

The driving force behind the panel is Frank von Hippel, a physicist and professor of public and international affairs at Princeton. He is the quintessential American citizen-scientist (and a grandson of James Franck). Like Pauling, Frank von Hippel is in his element writing academic papers as well as op-eds, briefing policy makers around the world, and standing in a demonstration with a placard in his hand.

Under his leadership, the panel tries to explain to policy makers and the public that the control and elimination of fissile materials is critical to nuclear weapons disarmament, to halting the proliferation of nuclear weapons, and to ensuring that terrorists do not acquire nuclear weapons.

We have drafted a fissile material cutoff treaty. It is now an official United Nations document and could be a basis for negotiations—when policy makers are ready.

In the longer term, however, the prospects frankly are grim, rather than merely gloomy.

The US is committed to a massive, long-term modernization of its nuclear complex and its nuclear weapons. As part of this effort, the Obama administration has announced plans to spend $355 billion over the next decade on nuclear weapons. In terms of annual spending, this will be on the scale of peak nuclear weapon spending during the Cold War.

The modernization will cover replacing US land-based and submarine-based nuclear missiles, and nuclear cruise missiles, as well as building next generation submarines and nuclear bombers and upgrading the nuclear weapons. It may cost a total of about $1 trillion over the next 30 years.

The new systems are expected to enter service sometime around 2030. They may last for at least 40 or 50 years. This is how old some of the current systems are, and they are not yet ready for retirement.

If this policy prevails, the US will have operational nuclear missiles at least until the year 2080. The world will be preparing to celebrate Linus Pauling's 180th birthday.

Some American politicians are already thinking on this timescale. In 2010, speaking as the secretary of state, Hillary Clinton declared, "Our goal [is] of a world someday, in some century, free of nuclear weapons" (Clinton, 2010).

Secretary of State John Kerry echoed this perspective during his confirmation hearings in 2013. Asked about eliminating nuclear weapons, Kerry said, "It is worth aspiring to, but we will be lucky if we get there in however many centuries the way we are going" (Kerry, 2013: 21).

When policy makers talk of a world free of nuclear weapons coming to pass "someday, in some century," or in "however many centuries," they may as well say nuclear weapons are here to stay forever. Nuclear weapons may become, in Niels Bohr's luminous phrase from 1944, a "perpetual menace to human security" (p. 106).

It seems unimaginable that nuclear weapons can remain indefinitely in the arsenals of the great powers—and in the arsenals of India, Israel, Pakistan, and North Korea—and not be used one day.

The danger may be greatest in South Asia. Pakistan and India are building up their nuclear arsenals as fast as they can. India is testing its first nuclear-powered submarine to carry nuclear-armed missiles. Pakistan is testing short-range battlefield nuclear weapons.

Nuclear nationalism is strong in Pakistan and India. For many, the Bomb is still a new and wondrous thing, a symbol of national power and strength. But even in South Asia there are scientists struggling against the Bomb (Hoodbhoy, 2013; Nayyar, 2014). It is a struggle against desperate odds and one that would have been familiar to Pauling.

For almost 30 years, Pakistani physicists Pervez Hoodbhoy and Abdul Hameed Nayyar have been warning their fellow citizens of the grave dangers of going nuclear. They have been denounced as traitors and as agents of foreign powers, labels that were once applied to Pauling.

They have Indian colleagues. The most notable are M. V. Ramana and Ramamurti Rajaraman, who shared the American Physical Society's 2014 Leo Szilard Award for their efforts to highlight the risks of nuclear weapons and nuclear energy programs and to promote peace and security in South Asia. I have been fortunate to work with all of them over the years as part of the program we have at Princeton University.

The situation in South Asia is becoming more perilous with each passing year. Pakistan and India are arming themselves and at the same time becoming increasingly wrapped up in the great competition between the United States and China for dominance in the coming century.

The United States is seeking to recruit India as a strategic ally to balance the rise of China. For its part, China is building up its long-standing ally, Pakistan. The four countries are tied together in an ever-tightening knot of insecurities, expectations, arms racing, and war planning.

There is reason to believe nuclear war in South Asia could have devastating global consequences. Scientists Alan Robock and Brian Toon and others have used modern climate models to explore the large-scale, long-term effects of a limited nuclear war between Pakistan and India.

They looked at what would happen if India and Pakistan used 50 Hiroshima-sized weapons each. The targets were assumed to be cities in the other country. The models showed that the smoke from the burning cities would rise high into the atmosphere, covering the globe and darkening the sky.

The absorption of sunlight by the smoke and soot would trigger global cooling that could persist for more than 25 years. Average surface temperatures would fall to their coldest in the last 1,000 years. There would also be worldwide ozone loss. The combination of prolonged cooling and ozone loss could devastate food supplies around the world.

The most recent study concludes, "It is conceivable that the global pressures on food supplies from a regional nuclear conflict could, directly or via ensuing panic, significantly degrade global food security or even produce a global nuclear famine" (Mills et al., 2014: 14). It is a terrifying forecast.

At the same time, there are signs of the political will in many countries to seek nuclear disarmament. In 2013, 128 states together with the Red Cross Movement, United Nations agencies, and civil society gathered in Oslo at a Conference on the Humanitarian Impact of Nuclear Weapons. There was a follow-up conference in February 2014, in Mexico, in which 146 countries participated. The third conference in this series, held in Vienna in December 2014, brought together representatives from 158 countries.

The goal in all these meetings was to remind the world of the catastrophic effects of nuclear weapons use. A principal finding of the Vienna conference was that:

> The impact of a nuclear weapon detonation, irrespective of the cause, would not be constrained by national borders and could have regional and even global consequences, causing destruction, death and displacement as well as profound and long-term damage to the environment, climate, human health and well-being, socioeconomic development, social order and could even threaten the survival of humankind. (Federal Ministry for Europe, Integration and Foreign Affairs, 2014: 1)

Pauling, I believe, would have been delighted to see how the ideas that he and other scientists struggled so hard to teach the world have now become common sense to so many. In many ways, the battle of ideas has been won. The world understands the danger of nuclear weapons. All we lack is the aroused understanding and insistence of the people of the United States and the world to demand an end to nuclear weapons. This is where the scientist has to step aside and the citizen has to step forward.

Editor's note

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Author biography

Zia Mian is a physicist at Princeton University's Program on Science and Global Security. He is a founder member and as of 2015 co-chair of the International Panel on Fissile Materials and co-author with Harold Feiveson, Alexander Glaser, and Frank von Hippel of *Unmaking the Bomb: A Fissile Material Approach to Nuclear Disarmament and Nonproliferation* (MIT Press, 2014).