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Responsibility of Science

AN UNFINISHED STORY

Are scientists responsible for the consequences of their discoveries? Up until the first decades of the 20th century, such a question would be considered ridiculous.

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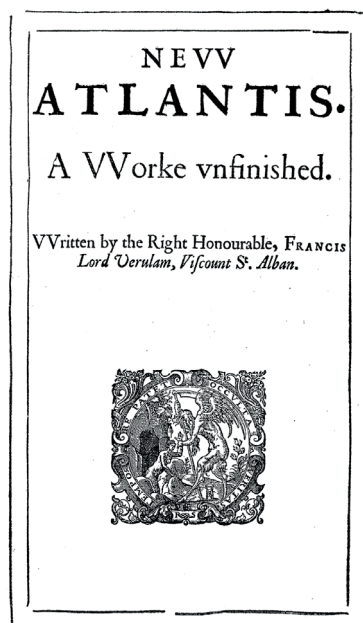
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Since the time of Francis Bacon and his *New Atlantis* (1626), the entire project of modern science has been closely linked to the utopian vision of complete dominion over nature. Scientific

developments were expected only to bring benefits, and ignorance was believed to be the source of the problems plaguing humanity. The Enlightenment and positivism reinforced the belief that the development of science is inextricably linked with progress in all spheres of human life.

This narrative was overshadowed by the rising backlash against the consequences of industrialization at the beginning of the 19th century. The actions taken by the Luddites destroying mechanical looms under the cover of night, as well as the works of Romantic poets who perceived rail transport as a threat to the natural beauty of the rural landscape, signaled the gradual rise of technoscepticism in European culture. Despite these voices of dissent, most scholars continued to believe that progress was worth its price and that any potential negative effects could be overcome with further scientific advancements, thus cementing the central role of science in modernization processes.

Title page of Francis Bacon's
New Atlantis from the
second edition of *Sylva
Sylvarum: or A Naturall
Histories* from 1628



SOURCE: WIKIMEDIA COMMONS, LICENCE: PUBLIC DOMAIN, MARK 1.0

The Fall of Idols – World Wars and the Crisis of Science

When considering the broader cultural change and the rise of criticism against modern science, World War I was a turning point, as it was during this time that scientists were harnessed in the war machine on such a massive scale for the first time. The story of chemist Clara Immerwahr, wife of the Nobel Prize winner Fritz Haber, is emblematic in that sense – she committed suicide after the poison gas developed by her husband had caused the deaths of thousands of soldiers at Ypres. This newfound awareness of



A British crew of a Vickers machine gun in type PH gas masks, near Ovillers during the Battle of the Somme, July 1916

the potentially negative effects of science led many scientists to become intensely involved in politics during the interwar period, especially in progressive and socialist movements. Science was still seen as a source of progress, but not just any science – only well-targeted science. Many idealistic students who felt repugnance toward the military applications of chemistry and physics in ballistics and electrical engineering turned to purely theoretical research, such as mathematics or theoretical physics, which was intended solely to broaden the understanding of the world. These young pacifists did not know that their disciplines would prove crucial in the next conflict.

That is because, although World War I initiated a paradigm shift, it was World War II that fully reformed the way of thinking about the relationship between science and politics in the Western world. There is no date more important in the history of scientific social responsibility than August 1945, when

atomic bombs exploded in Hiroshima and Nagasaki, leading to the deaths of at least 150,000 people from both burns and radiation sickness. The success of the Manhattan Project proved that the world was entering an era in which political and military power was directly linked to the science capital of a given nation. At the same time, scientists had never been so explicitly blamed for building the deadliest weapon in human history. The traditional argument that scientists had no influence on how politicians use their inventions became difficult to maintain.

Physicists Against the Bomb and Armament Race

After the war, many researchers involved in the development of the atomic bomb became actively engaged in anti-war activism, believing that scientists

Photo of an atomic cloud hovering over Nagasaki on August 9, 1945

could no longer remain silent about how their work was being used. One of the first important documents expressing the idea of scientists' co-responsibility regarding the application of scientific research was a report written on the eve of the bombing of Hiroshima and Nagasaki by the Nobel Prize winner James Franck, one of the directors of the Manhattan Project, advising against the use of the bomb on Japanese cities. It was the first of many public declarations

criticizing nuclear weaponry drafted by prominent scientists, such as the Russell-Einstein Manifesto of 1955 and the German Göttingen Manifesto of 1957, in which former members of the Nazi atomic program, among others, expressed their opposition to plans to deploy nuclear weapons in West Germany.

The 1960s and 1970s were a golden age for pacifist scientists such as the Nobel Prize winner in chemistry Linus Pauling, whose involvement in the anti-nuclear movement was crucial for the establishment of the first international agreements limiting nuclear testing. Pauling was awarded the Nobel Peace Prize in 1962 for his achievements in this field. Another recipient of this award in 1975 was physicist Andrei Sakharov, co-creator of the Soviet hydrogen bomb, who was critical of his mother country's policy on armaments. The list of physicists who won the Nobel Peace Prize closes in 1995 with our compatriot, physicist and radiobiologist Józef Rotblat, co-founder of the Pugwash pacifist conferences bringing together scientists critical of the military applications of atomic energy.

Biology as a New Frontier in the Struggle for Scientific Responsibility

Just as chemistry became the target of pacifist movements after World War I, nuclear physics suffered a similar fate after 1945. Many young physicists abandoned their discipline and devoted themselves to dynamically developing molecular biology, whose promise was to understand the mysteries of life, overcome diseases, and tackle the threat of famine. Initially, no one anticipated its potentially negative outcomes, but this post-war optimism underwent a review. Although the discovery of the DNA structure by Watson, Crick, Franklin, and other researchers in 1953 paved the way for biotechnology with its revolutionary promises, people also realized its potential threats to both human health and the stability of ecosystems. The result of this reflection was an international conference in Asilomar, California, in 1975, which became a milestone in the discussion on the ethics of genetic research and laid the foundations for modern systems of science evaluation. While, in the case of nuclear physicists, the discussion of responsibility for the military applications of their research was secondary to the construction of nuclear weapons, and responsibility itself was manifested through political involvement, biologists sought to incorporate the discussion of responsibility into the research process itself in order to anticipate potential ethical or ecological problems.

The latter dimension, in particular, has grown significantly in importance. Ecology, which flourished



SOURCE: NATIONAL ARCHIVES, IDENTIFIER: 535795, LICENCE: PUBLIC DOMAIN

after 1945 with the formalization of the concept of an ecosystem, was elevated in the 1960s and 1970s to the status of a key discipline in discussions on both genetic engineering and nuclear weapons (in the context of the circulation of radioactive elements). Ecologists increasingly took on the role of reviewers of scientific and technological progress, warning against the dangers posed by new technologies. Since the 1970s, chemistry in particular has been in the crosshairs of ecologists.

Chemistry as an Engaged Science par excellence

The impressive advances in nuclear physics and molecular biology largely eclipsed the development of chemistry in the aftermath of World War II. Meanwhile, chemistry exerted a far more direct influence on everyday life than the other two disciplines. The mass production of plastics, detergents, and synthetic fertilizers dramatically altered the molecular composition of everyday objects within just a few decades, without prompting an adequate debate on the social and cultural consequences of these transformations.

However, critical voices grew louder and ever more frequent. Biologist Rachel Carson, in her famous book *Silent Spring* (1962), sounded the alarm about the disastrous environmental effects of pesticide abuse. Subsequent tragedies – such as mercury poisoning in Minamata Bay, Japan (1950s–1960s), dioxin contamination in Seveso, Italy (1976), or the extremely lethal explosion in Bhopal, India (1984) – permanently transformed the perception of chemistry.

These dramatic events prompted many chemists to reflect, as they perceived them not merely as inevitable risks of the chemical industry, but as the consequences of the prevailing approach to practicing chemistry as a science. They emphasized that their discipline had focused for too long on a reductive model of synthesis conducted under laboratory conditions, largely detached from the broader environmental and social contexts in which chemical products are ultimately applied. In Germany, scientists such as Arnim von Gleich and Hermann Fischer propagated the concept of “soft chemistry” in the 1980s and 1990s as a holistic response to the challenges facing their field. Meanwhile, in the United States, Paul Anastas and John Warner formulated the concept of “green chemistry” in the mid-1990s, advocating the prevention of toxin and pollutant formation at the molecular level. Nowadays, the view that chemists must actively reshape their research practices to better address societal challenges has become widespread, and the number of publications on green



SOURCE: SMITHSONIAN INSTITUTION ARCHIVES, ACCESSION 90-105, SCIENCE SERVICE RECORDS, IMAGE NO. SIA2008-0392

Rachel Louise Carson (1907–1964)

An outstanding biologist and writer who initiated the modern ecological movement with her 1962 book *Silent Spring*. Describing the dangers of chemical pesticides, the book led to a nationwide ban on DDT and other pesticides, in addition to sparking a movement that eventually led to the creation of the United States Environmental Protection Agency (EPA).

and sustainable chemistry is growing rapidly, accompanied by increasingly sophisticated research evaluation systems. However, this formalization comes at a cost.

Delegated Responsibility

The landmark 1987 UN report by Gro Harlem Brundtland, which defined the term *sustainable development*, played a pivotal role in shaping the discourse on the social responsibility of science. The science of the future was envisioned as “balanced” and focused on a holistic consideration of its consequences. New concepts have since emerged, such as *life cycle assessment* and *technology assessment*, aiming to evaluate the effects of processes, products, or technological solutions in the “real world” beyond the strictly controlled conditions of laboratory experiments. In addition,

increasingly sophisticated analyses have been conducted on the effects of broadly defined pollutants on the environment (e.g., ecotoxicology, climatology), alongside disciplines focused on protecting the natural world from human intervention (e.g., conservation biology).

The social responsibility of science, initially an individual and deeply human response to the dramatic applications of science during the world wars, has now been quantified and integrated into the academic and scientific systems. Nowadays, a microbiologist or chemist does not necessarily need to exhibit the civil courage exemplified by Pauling, Rotblat, or Carson. A panel of experts evaluates the ethical aspects of their project, while a relevant regulatory agency will ensure that the outcomes of their work do not harm anyone. The researcher's conscience remains clear, without having to meditate ethical dilemmas related to the

driven by the conviction that an alternative science – one that is more socially and ecologically engaged – was possible.

The New Atlantis, the utopia discussed by philosophers such as Ernst Bloch, serves as the founding myth of modern science, without which science loses its significance and is reduced to a role subservient to politics or economics. Social responsibility, therefore, is closely intertwined with the project of modern science. Socially engaged scientists, aware that science must serve the collective good – such as Pauling or Carson – do not transgress by expressing political opinions; on the contrary, it is in such individuals that the true spirit of modern science is most fully realized.

Reflection on the social consequences of research – its significance and purpose – should constitute an integral part of the scientific work performed by every researcher. Abandoning this ambition, or delegating it to others, undermines the emancipatory nature of modern science and inevitably erodes social trust in scientists and the outcomes of their work – a process that is already becoming evident today. To prevent the complete degradation of the role of science, successive generations of researchers must redefine their mission by exploring the historical and philosophical roots of their disciplines, thereby situating the significance of modern science within the broader context of culture and civilization. The history, philosophy, and sociology of science must become both a fundamental part of higher education and a living subject of collective critical self-reflection. The challenge lies in the fact that this self-learning process requires time, which is difficult to accommodate in a world where the pressures of productivity (publications, grants, and teaching) encourage narrower specialization and reinforce utilitarian models of thinking.

The philosopher of science Isabelle Stengers compares modern science to fast food. This “fast science,” driven by temporary trends and oriented towards immediate gratification, is ultimately highly detrimental to the research community which engages in it. The remedy lies in slow science, a more responsible and intellectually enriching mode of reflection. The primary objective of scientists and science administrators today should be to envision what such a model of slow science might look like – one that rewards social engagement, critical self-reflection, and the narrowing of the gap between the humanities and exact sciences. The imperatives governing modern technologized economy will undoubtedly hinder any reform in this direction, but outlining the framework of a “reborn New Atlantis,” renewing the social contract on which modern science is founded, appears to be a necessary step today, even if it bears fruit only in distant future. ■

We need a “New Atlantis,” a social contract on which the science of the future will be based.

use of artificial intelligence in military drones or the patenting of genes in crops intended for markets in developing countries. Whether funding will be allocated for ecotoxicological studies on the molecules the chemist has synthesized remains firmly beyond their immediate sphere of interest. This delegation of responsibility, which undoubtedly offers many practical advantages – since no individual is able to independently assess the full social consequences of their work – is also a delegation of reflection on the broader meaning of scientific research.

Back to the Roots

Bacon's *New Atlantis* defined an objective for modern science: collective improvement of living conditions through the application of the power of reason. For centuries, this vision has served as a force driving researchers to seek understanding of the natural world and apply this knowledge in the service of humanity. In the 1970s, Bacon rightly found himself at the center of criticism from ecologically minded philosophers (Carolyn Merchant, Ernst Friedrich Schumacher, Isabelle Stengers) due to the language in his work suggesting the need to “subordinate” nature, which, in their view, contributed to the ecological crisis. Nevertheless, even Bacon's fiercest critics were

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