Press release
30 April, 2021

In the Humanities category

The Frontiers of Knowledge Award goes to Gerald Holton for articulating the cultural dimension of science and the liberating power of scientific rationality

- **The professor of Physics and History of Science** at Harvard University is a towering figure in the thought of the last third of the 20th century and the present day, whose many publications have explored the role of scientific knowledge in shaping culture, and the ways in which the cultural matrix of each historical period informs the elaboration of scientific theories and models in a mutually reinforcing process, conditioning in an essential way the very practice of science

- **Holton has recast the defense of the value of rationality** and objective knowledge, open always to verification and revision, in contrast to the exaltation of irrationality associated with populist movements which paves the way for totalitarianism, exclusion and the persecution of minorities

- **On analyzing Einstein's papers for the first time,** he identified what he called "themata," very general concepts and ideas that have emerged recurrently – and often unconsciously – throughout history in the thinking of great scientists: concepts like symmetry, causality or the search for the unity of fundamental forces

- **In his work, he has exemplarily laid bare the fundamental role of science** not only in improving health and furthering wellbeing and technological development, but also in the shaping of culture and the fostering of rationality, equipping society to address its collective challenges beyond social, ethnic or national barriers

- **He is one of the most thoughtful analysts and incisive critics of the "anti-science" phenomenon,"** warning that the cult of irrationality, relativism in the face of objective truth, and the proliferation of pseudosciences vs. scientific knowledge – subject to continual review and improvement – conform a cultural matrix that interacts with populism and nationalism to create

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a dangerous climate favorable to the rise of totalitarian regimes and phenomena of minority exclusion or annihilation

The BBVA Foundation Frontiers of Knowledge Award in the Humanities category has gone in this thirteenth edition to Gerald Holton "for his numerous seminal contributions to the history of 19th and 20th century science, in which he has shown a special sensitivity to cultural, philosophical, and sociological and gender contexts," says the committee in its citation.

Holton, it continues, has developed "a reasoned analysis of the complex phenomenon of anti-science, and its role in totalitarianism."

The citation refers also to "his innovative contributions to science education, his decisive role in the preservation of Albert Einstein's documentary legacy, and his studies into the fate of children forced to flee Nazi Germany."

Holton, a professor of Physics and History of Science at Harvard University (United States), is a towering figure in the study of how science shapes a society's culture, and the ways in which the cultural matrix of each historical period intimately conditions the practice of science by informing the elaboration of theories and models.

The new laureate explains that he has sought to show in his work "how science is infused with its background, instead of treating it as if it had come down from heaven all by itself." His way of practicing science history is to place the focus on its conceptual and cultural dimension. "Science," he has written, "should treasure its history and historical scholarship should treasure science."

Gerald Holton was born in Berlin in 1922. The rise of Nazism forced his family to move to Vienna, where he spent most of his childhood and adolescence. At age 16, he found himself fleeing once more after Austria was annexed, first to the United Kingdom and two years later to the United States, which became his home and where he has spent his entire academic career. He is one of the bare 7% of Jewish children, out of 1.6 million, who survived the Holocaust. An experience that underpins much of his later work.

Science shapes culture and vice versa

Holton's work upholds the role of science in shaping the culture of each age, without ever falling into scientificism, the belief that beyond scientific language lie only irrationality and meaningless. On the contrary, he argues that many fields, art and literature among them, are instrumental in

giving form and content to a society's culture. He sees science, however, as an essential civilizing force, contributing not only to economic growth and societal welfare but also, at a deeper level, to the configuration of modes of thinking, decision-making and behavior in each time period, on both the individual and collective plane.

The pillars of science – he reminds us – are truthfulness, objectivity and the generation of knowledge that is not immutable but subject to scrutiny by others, and therefore always subject to revision in the light of new evidence or more elegant and general conceptual models. So as well as health, economic growth and technological efficiency, science fosters rationality and thus adds to society's ability to solve its problems. Yet his work has also shown how science itself does not develop in a capsule, isolated from the cultural (not just socioeconomic) fabric, but rather permeates through it in breadth and depth. Or as Holton puts it, "science is part of a tapestry, it is woven into a culture."

The physicist, historian and now Frontiers of Knowledge laureate in Humanities was one of the first voices calling for an urgent and imperative effort to relay scientific culture to the general population, a cause he has advocated for over half a century in a way that is both perceptive and respectful of other sources of general culture. And not just because of the immediate utility of technoscientific knowledge, but of how scientific thought can aid in cognitive orientation, and the construction and development of society's mental maps or mindset. Holton's extensive body of work has foregrounded the fundamental role of scientific culture as a unifying force for all humanity.

"Themata" in Einstein and other great scientists

As a scholar of science history and how scientific discoveries are made, one of Holton's greatest contributions has been the identification of what he called "themata," the crystallization of very general ideas that emerge recurrently – often unconsciously from their place in the underlying cultural fabric – in the thought of history's most creative scientific minds; among them symmetry, causality and the search for the unity of fundamental forces.

Holton picked up on these "themata" in the course of studying Albert Einstein's papers, which he was the first to archive and make available to the scientific community. Following the death of the German physicist in 1955, a colleague at Harvard had suggested he prepare a history of Einstein's discoveries for a forthcoming tribute event. Finding that there had been little work done on the subject, he approached the Institute for Advanced Study at Princeton, where Einstein spent the closing years of his career and where all his writings and correspondence were kept (a total of over

40,000 documents).

With the aid of Einstein's secretary, Helen Dukas, Holton spent two years classifying and analyzing this material. Realizing its incalculable value, he became the first researcher to study this legacy from the standpoint of the conceptual history of science. "I thought, it's a moral obligation to try to put this into an archive that scholars can use," he recalled in an interview. In fact through his study of the great man's scientific publications, correspondence and other papers, Holton would make Einstein himself an object of study, as Newton or Darwin were before him. It was while doing so that he identified the themata that show the stamp of cultural ideas and metaphors in scientific thought, the footprint of culture in science.

"It became clear to me – to my surprise, I was not prepared – that Einstein obeyed an inner epistemological compulsion, as do so many scientists, of seeing science through certain keyholes, certain lenses. I called them themata – themes – namely, ideas which are so imprinted in them that they may not have been fully aware of them; these determine the basic underlying structure of their work."

In Einstein's case, among the most repeated concepts were the search for unity in nature's forces; formal rather than phenomenological explanations; causality; completeness; and continuous versus discrete phenomena. These same concepts are at the core of the work done by other great scientists, from Johann Kepler to Niels Bohr, as Holton documented in his book *The Thematic Origins of Scientific Thought* (Harvard University Press, 1973).

Themata, in sum, are constructs emanating from each scientist's particular cultural matrix, which they incorporate, at times unconsciously, into their work, and that condition their style or manner of thinking. Holton defines them as ideas that act as a kind of conceptual template, allowing a scientist to focus on certain objects, phenomena or connections.

The danger of "anti-science"

Holton is also one of the authors who has most incisively pinned down the phenomenon of "anti-science," most visibly present in the rise of science-denying social movements, while alerting to the manifold dangers it poses. In a number of his articles, he insists that although science may advance in the laboratory, and, through technology, in people's lives, there is no guarantee that a society's general culture will advance in the same direction. As was brutally evident in Nazi Germany, advances in science may be accompanied by values and doctrinal currents that set their face

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against scientific rationality, objectivity and truth, while exalting emotions and impulses uncoupled from or even at odds with ideas subject to formal, empirical scrutiny.

Holton witnessed the rise of Nazi barbarism with his own eyes in an apparently civilized society, and from that early experience has opined with the utmost force and clarity - particularly in his work *Science and Anti-Science* - that the exaltation of irrationality, when combined with populism and nationalism, is an equation whose result all too easily leads to totalitarian movements and regimes.

"The record from Ancient Greece to Fascist Germany and Stalin's USSR to our day shows that movements to delegitimate conventional science are ever present and ready to put themselves at the service of other forces that wish to bend the course of civilization their way – for example, by the glorification of populism, folk belief and violence, by mystification, and by an ideology that arouses rabid ethnic and nationalistic passions. (...) Parasciences by themselves may be harmless enough except as one of the opiates of the masses, but when they are incorporated into political movements they can become a time bomb waiting to explode," he wrote in *The Advancement of Science, and Its Burdens* (1986).

For Holton, we can never assume that scientific progress will automatically be accompanied by a parallel advance in a society's cultural and civilizational framework. Rather, he has alerted to the danger of pathological currents among the intellectual class, who may see scientific knowledge as a mere social construct, just one more discourse that has no special claim to deciding what is true. This was the case, for instance, with postmodernism and certain trends in the social sciences, humanities and essayism. As Holton sees it, this phenomenon betrays a perilous, irrational delegitimization of the whole scientific *auctoritas*, "a throwback to Nietzsche, in his most extreme form, where everything is all the same to everyone, everything is open to opinion."

As he warned in his 1992 paper, "How to think about the 'anti-science' phenomenon": "It is prudent to regard the committed and politically ambitious parts of the anti-science phenomenon as a reminder of the Beast that slumbers below. When it awakens, as it has again and again over the past centuries, and as it undoubtedly will again someday, it will make its true power known. Those who care to learn the lessons of the past may be well advised to try to defang the counter-vision even in its present, less virulent state."

As well as the substantive content of Holton's extensive output and his love of rationality as a force for peaceful coexistence, the committee remarked that "his body of work, with its transparent

prose, stands as a milestone in the essential task of uniting the two cultures, the scientific and the humanistic."

A life marked by Nazism

By the time of Holton's birth, in 1922 Berlin, fascist gangs were already attacking Jewish politicians and intellectuals, a dramatic situation that led his family – the father a lawyer, the mother a physiotherapist – to take refuge in their native Austria. Holton grew up in Vienna, but by 1938 the tentacles were spreading, as evidenced by the terrifying Night of Broken Glass.

By pure chance – children's destination was decided by a draw – Holton, his brother and a further 10,000 children were able to leave without their parents for the United Kingdom, with the aid of the Quaker organization Kindertransport. There Holton studied electrical engineering until in 1940 he was able to rejoin his family in the United States. At the time some American universities were offering places to European refugees, and Holton was able to enroll at Wesleyan University in Middletown, Connecticut, where he earned a physics degree in 1941, and a master's in the same discipline in 1942.

During the Second World War he was invited, as were many other physicists, to join the Manhattan Project working on the atomic bomb at Los Alamos (New Mexico). Holton turned it down, a decision he ascribes to his respect for the spiritual values of the Quakers who had cared for him in Britain. He did, however, contribute to the war effort in what he considered a defensive role, teaching navy officers how to use radar, and forming part of the military research team stationed at Harvard.

After the war, in 1947, he obtained his PhD from Harvard with a study on the structure of matter at high pressure, under the supervision of Percy Williams Bridgman, a brilliant scientist distinguished with the Nobel Prize in Physics in 1946. His association with Harvard has continued to this day.

Science education as part of culture

At the age of thirty, in 1952, Holton got to head his own laboratory of high-pressure physics. But he was also teaching what was then a left-field subject, an introduction to physics as culture, combining strictly scientific contents with others drawn from the history and philosophy of science. This would provide the seeds for his first book, *Introduction to Concepts and Theories of Physical Science*, now considered a seminal work with its focus on science history, the nature of discovery,

reasoning and the elaboration of concepts as inherently fascinating themes, and not just a way to make the content more attractive.

"When I got my position at Harvard and had to teach physics I thought that I would write a book and in this book, unlike any other book at the time – it was very courageous and maybe stupid – I also put in the history of science, technology and the other sciences, not just physics but chemistry and astronomy as well, and a little bit of biology (...). The students really appreciated it."

Decades later, Holton would publish a revised edition of this landmark work, which he titled *Physics. The Human Adventure* (2001). In it, he stresses the value of including humanities content, like the history and philosophy of science, in the science curriculum: "...so if one of your skeptical colleagues, on hearing you might engage in such a plan in your science teaching, came to you, horrified about it all, saying 'There is no time for such extras...' you have an answer: The humanistic approach to science teaching has been tried, and it works. If I were to leave out what you regard as extras, I would be apt to teach dead science, and my students would know it. Instead, I shall take on the more difficult task that my sense of obligation to my students requires, and they will thank me for it."

Holton says he has the humanistic education he received in Vienna to thank for this integrating vision of science and culture: "In my high school period, in my *gymnasium* in Vienna, you had to go very seriously into everything from mathematics to poetry, from biology to history and so on, (...) and it was very important to me to get the idea of the continuity of culture across the whole field from poetry through mathematics."

Scientific culture as a mainstay of society

His passion for science history fueled his conviction that scientific culture is one of the mainstays of society. In 1956 Holton entered the U.S. Academy of Arts and Sciences and was asked to take on the editorship of the magazine *Daedalus*. He decided to use it "to give the intellectual community a strong voice of its own," opening its pages to current issues like disarmament of the ethics of human experimentation.

In the mid-1960s, he had the following to say about strengthening scientific culture to better confront society's challenges: "We must change our culture in order that it may be more conducive

to turning out enough intelligent administrators, educators, etc., for they are needed to operate the vastly accelerated worldwide scientific revolution without which we are not likely to survive the major threats." (*Science for Nonscientists. Criteria for College Programs*, 1964).

In 1981 Holton was the first scientist to deliver the prestigious Jefferson Lecture, invited after a selection process by the independent federal agency, the National Endowment for the Humanities (NEH). Not long afterwards, he took up the presidency of the History of Science Society.

Women scientists and successful immigrants

His later career stage has been no less productive. In the 1990s, Holton became aware of how few women were working in the majority of science areas, and joined forces with the sociologist of science Gerhard Sonnert to launch the research collaboration Project Access, whose findings were set out in two publications: *Who Succeeds in Science?: The Gender Dimension* (1995), and *Gender Differences in Science Careers: The Project Access Study* (1995)

In a 2015 interview Holton explained one of the main conclusions of this effort: "We took a group of men and women and asked them to submit what they regarded as their best work, and took away their names and submitted it to a group of distinguished scientists to give the quality. And it turned out that on average what the women were working on was as good or better than what the men were working on, and it had an additional thing, namely that the women tended to look for really difficult problems, and worked on them for a long time, whereas the men looked for solvable problems and got many publications out of it. So to the men it's more of a career in science and to the women it's more of a calling in science."

Another area where Holton has done pioneering work is the question of how immigrants can transform a society. Again with Sonnert, he began an exhaustive study of the life stories of children who had reached America fleeing from the Nazis. Both admitted their surprise at the conclusions of the project: despite the dreadful obstacles these children had had to overcome, they ended up [on average] with highly successful professional careers.

Humanities committee and evaluation support panel

The committee in this category was chaired by **Carmen Iglesias,** Director of the Real Academia de Historia, with **José Manuel Sánchez Ron**, numbered member of the Real Academia Española and Emeritus Professor of History of Science at the Universidad Autónoma de Madrid acting as

secretary. Remaining members were **Ignacio Bosque**, numbered member of the Real Academia Española and Emeritus Professor of Spanish at the Universidad Complutense de Madrid; **Isabel Burdiel**, Professor of Contemporary History at the University of Valencia; **Violeta Demonte**, Emeritus Professor of Spanish at the Universidad Autónoma de Madrid; and **José María Fernández Cardo**, Professor of French at the University of Oviedo.

The **evaluation support panel** of the **Spanish National Research Council (CSIC)** was coordinated by **M. Victoria Moreno**, the Council's Deputy Vice President for Scientific and Technical Areas, and formed by: **Jon Arrizabalaga Valbuena**, research professor at the Mila i Fontanals Institution (IMF); **Esther Hernández Hernández**, scientific researcher at the Institute of Language, Literature and Anthropology (ILLA); **Ignacio Montero Ruíz**, Deputy Coordinator of the Global Society Area and scientific researcher at the Institute of History (IH); **Consuelo Naranjo Orovio**, research professor at the Institute of History (IH); and **Fernando Rodríguez Mediano**, scientific researcher at the Institute of Languages and Cultures of the Mediterranean and the Near East (ILC).

About the BBVA Foundation Frontiers of Knowledge Awards

The BBVA Foundation centers its activity on the promotion of world-class scientific research and cultural creation, and the encouragement of talPHent.

The BBVA Foundation Frontiers of Knowledge Awards recognize and reward contributions of singular impact in science, art and the humanities, privileging those that significantly expand the frontiers of the known world, open up new fields, or emerge from the interaction of various disciplinary areas. The goal of the awards, established in 2008, is to celebrate and promote the value of knowledge as a public good without frontiers, the best instrument at our command to take on the great challenges and opportunities of our time. Their eight categories are congruent with the knowledge map of the 21st century, according a differential weight to areas of particular relevance and dynamism in recent decades such as the environment, information and communication technologies and biomedicine, alongside other areas like basic sciences, economics, social sciences, the humanities and the supremely creative realms of contemporary music and opera.

The BBVA Foundation is aided in candidate evaluation in the eight award categories by the Spanish National Research Council (CSIC), the country's premier public research organization. CSIC appoints evaluation support panels made up of leading experts in the corresponding disciplinary domain, who are charged with undertaking an initial assessment of candidates, and

drawing up a reasoned shortlist for the consideration of the award committees. CSIC is also responsible for designating each committee's chair and participates with the BBVA Foundation in the selection of its members, thus helping to ensure the objectivity and merit of the selection process.

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