The suspected spy who might have won a Nobel

Half-Life
The Divided Life of Bruno Pontecorvo, Physicist or Spy

Frank Close
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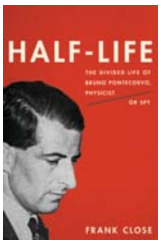
Reviewed by Spencer Weart

Italian-born physicist Bruno Pontecorvo was the protagonist in one of the most fascinating and enigmatic tales of the atomic era. Handsome, charming, and ebullient, he worked in Canada and the UK on secret nuclear reactor projects before disappearing, along with his wife and children, in 1950. Most people supposed that Pontecorvo had been spying for the Soviet Union and defected before he could be arrested. Five years passed before the Soviets revealed that he had indeed fled into their arms. Had Pontecorvo lived a secret life as a spy since the mid 1940s? Or, as McCarthyism closed in, had he simply left the West for what he felt would be a better scientific environment? In *Half-Life: The Divided Life of Bruno Pontecorvo, Physicist or Spy*, physicist Frank Close can conclude only that the spying is likely but not proven.



The scion of a wealthy, liberal Jewish family, Pontecorvo studied physics at the Sapienza University of Rome. In 1934 he became the youngest member of Enrico Fermi's nuclear research team there. Fermi and his team discovered that slow-neutron bombardment can induce radioactivity; Pontecorvo, who had been part of the group for only a few months, shared some of the credit. In 1936 the young physicist moved to the research group led by Frédéric Joliot-Curie and Irène Joliot-Curie in Paris, and there he remained, probably in response to the Italian regime's growing anti-Semitism. The Joliot-Curies and their circle, like many European antifascists, were deeply engaged with members of the Communist Party. Pontecorvo was swept along and in 1939 secretly joined the party.

In 1940 Pontecorvo and his family made their way out of France, one step ahead of the Germans. He wound up in Canada and became an important figure in the Anglo-Canadian project to build a heavy-water-moderated reactor. He then spent some time doing cutting-edge work on muon decay and related subjects before moving to the UK in 1949 to continue developing reactors. The following year, in the wake of Klaus Fuchs's confession that he had spied for the Soviets, frantic US agencies began taking a closer look at atomic scientists. They started to uncover Pontecorvo's Communist sympathies. That came to the attention of Kim Philby, a double agent high in the British intelligence service. Close hypothesizes that Philby informed his Soviet masters, who then took steps to extract Pontecorvo. But exactly what led to the physicist's defection remains obscure. If he did act as a spy, the information he possessed would have been useful but not of grave importance.

Pontecorvo and his family wound up in the Soviet nuclear research center in Dubna. Close suspects that Pontecorvo served as a consultant on the Soviet hydrogen bomb program, but evidently, the main thrust of the physicist's work was pure research on subnuclear particles. He had been fascinated by neutrinos ever since his days as Fermi's student, and in Dubna he made a number of significant theoretical contributions.

Among other discoveries, Pontecorvo is credited with recognizing the existence of two separate types of neutrinos, one associated with electrons and the other with muons; the concept was originally suggested by Gerald Feinberg. With Vladimir Gribov, he predicted the way neutrinos oscillate between the two different types. Close argues that had Pontecorvo been alive in 2002—he died in 1993—he might have received a share of that year's Nobel Prize in Physics for his theoretical work on neutrino oscillation.

Because of his confinement in the Soviet Union, where publishing and experimental opportunities were limited, his work was not widely disseminated. There are also elements of the tragic in Pontecorvo's life. His wife, unable to adapt to life in Dubna, spent long periods in a sanatorium, and Pontecorvo eventually realized that his faith in Communism had been a miserable mistake.

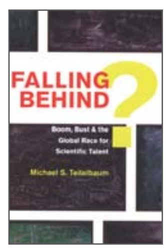
In addition to covering Pontecorvo's career, Close does an excellent job of explaining the science and history of nuclear and particle physics at a level appropriate to the general reader. Most of the story has been told before, notably in Simone Turchetti's *The Pontecorvo Affair: A Cold War Defection and Nuclear Physics* (University of Chicago Press, 2012), which gives less attention to the physics and more to the machinations of spy agencies and governments. Close has brought several new source materials to bear, and his book now stands as the most complete and readable biography of a remarkable individual and his extraordinary response to extraordinary times.

Spencer Weart is director emeritus of the Center for History of Physics at the American Institute of Physics. He has written extensively on the history of nuclear physics; his most recent book, *The Rise of Nuclear Fear* (Harvard University Press, 2012), was reviewed in PHYSICS TODAY (June 2012, page 55).

Falling Behind?
Boom, Bust, and the Global Race for Scientific Talent

Michael S. Teitelbaum
Princeton University Press, 2014.
$29.95 (280 pp.).
ISBN 978-0-691-15466-4

The US will soon have a large oversupply of scientists. Or maybe it will have an undersupply. American graduate education is failing, and research accomplishment will soon decline. Or maybe the opposite is true. If you read any of the many reports whose distinguished panels of authors say one or another of those things, you had better also check the citations to determine whether the methodology behind the claim has any validity.



One recent and illuminating contribution to the discussion is *Falling Behind? Boom, Bust, and the Global Race for Scientific Talent* by Michael Teitelbaum, a senior research associate in the Labor and Worklife Program at Harvard Law School. The book provides a clear, documented, and readable account of the many booms and busts in the number of scientists entering the US workforce over the past 70 years; the cycles frequently correspond to increases and decreases in government funding. Teitelbaum finds scant justification for the repeated claims of shortage. He discusses difficulties in determining an optimal flow of science students in the workforce pipeline, in relating the overall numbers of scientists to those for subspecialties, in comparing the US research population to other nations', in counting the number of postdocs in the US, and even in deciding whether to use the definition of "scientist" from NSF, the US Department of Labor, or another source.

Many reports in the past decade have presented troubling claims. Most notably, *Rising Above the Gathering Storm*, produced in 2005 by the National Research Council, warned of the diminishing quantity and quality of US students going into science and engineering. Congress passed the America COMPETES Act in 2007, partly in response to those alarming reports, and authorized large research-funding increases for NSF and the Department of Energy. The idea was planted in the minds of policymakers that our country's scientific workforce and scientific output were falling behind.

Although the actual appropriation for America COMPETES was derailed by partisan fights over the debt ceiling and the sequestering of federal funds, the American Recovery and Reinvestment Act (the "stimulus") did result in a surge of additional federal funding—tens of billions of dollars—to research agencies. But that is only the most recent occurrence in roller-coaster rhetoric and policy concerning the scientific workforce. Teitelbaum shows how similar the recent alarms are to those sounded over the decades, such as in the early years of the Cold War, following the launch of the Soviet Union's *Sputnik* satellite, and in the early 1980s during President Reagan's defense buildup.

Falling Behind? chronicles five episodes of alarms followed by funding increases to support more scientists, followed by downturns that sometimes led to hard landings. Finding flaws in the methodology used by those perennial alarms, Teitelbaum cites reliable independent studies to show that the calls for training more scientists were not based on well-founded estimates of supply and demand.

Despite methodological flaws in estimating the actual and desirable number of scientists, the recommendations of those jeremiad reports may still make sense. For example, there is always a need to educate the best students better and to close the achievement gaps in K–12 education. Also, foreign students who earn undergraduate or graduate degrees in science, engineering, and mathematics should be encouraged to remain in the US, rather than being forced out.

Even lacking a good economic analysis of the supply of US scientists, people from various perspectives will advance arguments for increasing the numbers. However, rather than general arguments about the military, industrial, or institutional advantages of having more scientists, Teitelbaum would prefer sound economic analysis. Whatever the justification, says Teitelbaum, funding agencies should pay more attention to the motivations and career paths of young scientists, whether or not they are likely to remain in the research workforce.

Teitelbaum makes clear that support for science should have a more rational basis than is frequently the case. He suggests that the principles advanced by *Science, the Endless Frontier*, Vannevar Bush's 1945 report establishing the US model for scientific funding, were good then and should be followed more consistently now. That is, funding for research should be awarded by peer review of proposals and administered primarily through universities and research institutes. Moreover, such funding should be stable, Teitelbaum insists, and not subject to boom-and-bust patterns.

With Teitelbaum's account of all the fuzzy thinking and unfounded claims about the scientific workforce over the years, *Falling Behind?* should add to the growing realization in policy circles that this country needs an independent institute for analysis of, and advocacy for, the scientific enterprise.

Rush D. Holt
American Association for the Advancement of Science
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Music and the Making of Modern Science

Peter Pesic
MIT Press, 2014. $40.00 (360 pp.).
ISBN 978-0-262-02727-4

Peter Pesic's *Music and the Making of Modern Science* ends with the following statement: "Science has followed music." In this magnificent book, trotting from Pythagoras to Max Planck and beyond, Pesic shows us again and again how music informed innovation, and he offers illuminating new insights into nearly three millennia of scientific developments. Pesic's rigorous analysis of source material allows him to confidently credit music for its critical role in the innovations of Johannes Kepler's astronomy, Leonhard Euler's topology, and Planck's quantized energy. It is a testament to Pesic's quiver of knowledge that he can so thoroughly examine the work of so many polymaths. That breadth can also be seen in the unique pedagogical approach of Pesic's home institution—St. John's College in Santa Fe, New Mexico—which uses mainly primary source materials in its science courses. For example, students read Hans Christian Oersted to learn about electromagnetism.

Over the course of 18 tight, graceful chapters, Pesic—a physicist, historian, and musician—builds his case. Many of the episodes will be familiar to students of the hard sciences. They include cosmological debates and the development of irrational numbers, field theory, and Schrödinger's wave equation. Indeed, a basic familiarity with physics and mathematics is necessary to take full advantage of the book—as is some basic music knowledge. Although its main appeal may be to readers interested in the connections between music and science, the book could be fruitfully employed as the main text for a college course on the history of science and music or even an introductory physics course.

Music, as Pesic presents it, is broadly defined, though limited to the Western tradition. In the examples offered, music's causal power as a conceptual force varied. For Isaac Newton, Euler, George Johnstone Stoney, and Thomas Young, music prompted insight (and sometimes confusion) through analogy. For Nicole Oresme, Kepler, Hermann von Helmholtz, and Planck, it was a personal love and practice of music that informed their science. And, as Pesic puts it, for Pythagoras, Plato, Johann Balmer, and Erwin Schrödinger (kind of), music was the "interface through which natural philosophy could connect with mathematics." That Pythagoras and Schrödinger both employed music as an interface reveals just how broadly music is defined in the text. It also underscores Pesic's claim that natural philosophy's search for cosmic harmony has followed music to the present, even if nowadays the role of music is generally unacknowledged.

It is always a bit unfair to point to what has been left out of a book, especially one that so impressively balances both breadth and depth, but there isn't a lot about music in *Music and the Making of Modern Science*. Besides the audio examples in the ebook—which I recommend over the physical copy—and a few discussions of composers sprinkled about, readers have little sense of the sound of the music heard by the principle actors in the book. I wanted to know more about what Young listened to on the church's organ. I wanted to know what operas Albert Einstein attended. I wanted to know more about the music that rang in those men's ears—music as they most commonly experienced it. Pesic does include a lot on music theory, music as an abstract interface, and musical instrument design. In his discussion of René Descartes, we witness music shifting from divine force to material phenomenon. But readers won't quite experience music as a cultural phenomenon.

That said, nothing in the fields of history of science or sound studies compares with *Music and the Making of Modern Science*. Scholarly monographs on the relationship between physics and music have focused on much narrower temporal and geographical settings—that includes my own book, *The Psychophysical Ear: Musical Experiments, Experimental Sounds, 1840–1910* (MIT Press, 2012). Two other excellent examples are Veit Erlmann's *Reason and Resonance: A History of Modern Aurality* (Zone Books, 2010) and Myles Jackson's *Harmonious Triads: Physicists, Musicians, and Instrument Makers in Nineteenth-Century Germany* (MIT Press, 2006). Edited volumes such as Trevor Pinch and Karin Bijsterveld's *Oxford Handbook of Sound Studies* (Oxford University Press, 2012) have made valiant efforts toward breadth but remain restricted to the modern era.

Pesic's brilliant, unique work fills a glaring need.

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Quantitative Plate Tectonics
Physics of the Earth—Plate Kinematics—Geodynamics

Antonio Schettino
Springer, 2015. $99.00 (403 pp.).
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During the past half century, plate tectonics has developed from an initially radical, paradigm-shifting view of Earth processes to the foundational support for essentially all branches of geology. One early, great success of plate-tectonic theory was the explanation of geological observations through quantitative, physics-based models.

Plate-tectonic theory is closely linked to its underlying fundamental physics of heat transfer, continuum mechanics, elastic-wave propagation, and electromagnetic processes. But hardly any university-level texts derive and focus on those connections. That gap is the one Antonio Schettino intends to fill with his *Quantitative Plate Tectonics: Physics of the Earth—Plate Kinematics—Geodynamics*.

What sets the book apart is not the specifics of its content; virtually all the covered material can be found in other geophysics texts. Rather, the framing of everything in terms of plate-tectonic processes is what distinguishes this from a wide range of theoretical geophysics texts. *Quantitative Plate Tectonics* was clearly designed for a course taught by the author, and although its