Historical Studies in Which Sciences? The Revolving Door of Engineering and Technology

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ABSTRACT

The first eleven volumes of *Historical Studies in the Physical Sciences* treated science for the most part as an academic, monodisciplinary pursuit of knowledge with little thought of application or contact with wider society. That changed abruptly in 1981 with Volume 12. Ever since, the journal's name has steadily broadened, while its content has come to include ever more interdisciplinarity and application. The place of science depicted in the journal's pages is now all of society, including industry and the engineering disciplines. One possible explanation for this shift, associated with Paul Forman, is that technology and applied research achieved cultural primacy over basic science after 1980. On this view, the journal is simply following society's lead in turning away from basic science. This article argues, instead, that the field of science and technology studies, and its aim to understand science-as-part-of-society, is now taken for granted by the journal's authors. On this view, the engineering sciences are simply one of several domains (alongside the social sciences, agricultural sciences, and biomedicine) where it is particularly easy to glimpse science's participation in wider society.

This essay is part of a special issue entitled "Looking Backward, Looking Forward: *HSNS* at 50," edited by Erika Lorraine Milam.

KEY WORDS: engineering science, applied science, Forman 3, epochal break, science and technology studies

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The following abbreviations are used: *HSNS*, *Historical Studies in the Natural Sciences*; *HSPS*, *Historical Studies in the Physical Sciences* and *Historical Studies in the Physical and Biological Sciences*; SSK, Sociology of Scientific Knowledge; STS, Science and Technology Studies.

Historical Studies in the Natural Sciences, Vol. 50, Number 1-2, pps. 41–49. ISSN 1939-1811, electronic ISSN 1939-182X. DOI: https://doi.org/10.1525/hsns.2020.50.1-2.41.

Historical Studies in the Natural Sciences (*HSNS*) has had three names in its fifty years, each prying its scope a little wider. Other essays in this issue reflect on what it has meant to move from publishing historical studies in the "physical sciences," to the "physical and biological sciences," to the "natural sciences." Here I explore whether the journal's name has broadened enough to accurately reflect its content. In recent years we have published a number of articles and reviews that could more easily be classed as historical studies in the social sciences, agricultural sciences, engineering sciences, and even biomedicine.[1] Is this a symptom of the journal's mission creep, which could be rectified either by taking a harder line on manuscript submissions or by changing the journal's name once again? Maybe. I take a different tack and ask whether our authors' inability to color within the lines of the journal's name tells us something interesting and useful about the culture and practice of science. I think it does, and I will try to make that case with particular reference to the evergreen question of the relationship between science and engineering.

GOES TO VOLUME 11

At least on the surface, the overflowing of categories I describe above was not very evident in the first decade or so of *Historical Studies in the Physical Sciences* (*HSPS*). The articles in Volumes 1 through 11 were coherent and reflected the journal's title. The physical sciences were taken to be, well, physics (sometimes including astrophysics) and very occasionally chemistry. The place of science was regarded as Central and Western Europe, with some sorties to the United States and Japan.[2] The articles within the pages of *HSPS* depicted science as an enterprise having little to do with industry, even if they acknowledged that a few scientists—e.g., Irving Langmuir, who appeared in Volumes 4 and 6—did work in industrial labs.[3] The contributions of figures such as

1. Austin R. Cooper, "'A Ray of Sunshine on French Tables': Citrus Fruit, Colonial Agronomy, and French Rule in Algeria (1930–1962)," *HSNS* 49, no. 3 (2019): 241–72; Johan Gribbe and Olof Hallonsten, "The Emergence and Growth of Materials Science in Swedish Universities," *HSNS* 47, no. 4 (2017): 459–93; Rebecca Lemov, "An Episode in the History of PreCrime," *HSNS* 48, no. 5 (2018): 637–47; Ksenia Tatarchenko, "Thinking Algorithmically: From Cold War Computer Science to the Socialist Information Culture," *HSNS* 49, no. 2 (2019): 194–225.

2. E.g., Kenkichiro Koizumi, "The Emergence of Japan's First Physicists: 1868–1900," *HSPS* 6 (1975): iv–108.

3. E.g., Robert E. Kohler, "Irving Langmuir and the 'Octet' Theory of Valence," *HSPS* 4 (1974): 39–87; and Kohler, "The Lewis-Langmuir Theory of Valence and the Chemical

Langmuir, Fresnel, and Helmholtz to technology, medicine, or other fields adjacent to the physical sciences were bracketed; what mattered about those figures was their achievements within the academic physical sciences.[4] Interestingly, the authors doing the bracketing published excellent histories of the life and engineering sciences elsewhere and/or in this journal during later eras: Paul Forman, Joan Bromberg, Rob Kohler, Terry Shinn, Peter Galison, Norton Wise, and more.

One can imagine that several factors bound the journal's offerings so tightly in those early years. A mix of editorial leadership, a relatively small and homogeneous community attached to the journal, and the influence of broadly Mertonian ideas about what should count as science—all of these influences surely played a role. What I find curious is that the journal was founded during a period of quite turbulent and widespread rejection of exactly the conception of science elaborated in its first eleven volumes. The journal's first issue in 1969 coincided with agitation across many Western European and North American societies—the home and research focus of most of the journal's authors—that amplified calls for scientists to become more socially responsible, more interdisciplinary, and more applied.[5] Yet the picture of the physical sciences presented in the journal's first eleven volumes was rather mono-disciplinary, ivory tower, and agnostic about application.

All that changed suddenly in 1981 with the two issues of Volume 12, which featured multiple articles about bombs, electrotechnology, and industrial research.[6] Lillian Hoddeson deserves particular credit, I think, for her article on "The Discovery of the Point-Contact Transistor." Note how her title slyly

Community, 1920–1928," *HSPS* 6 (1975): 431–68. Note, by contrast, how "physics" is equated to the "academic establishment" in Paul Forman, John L. Heilbron, and Spencer Weart, "Physics circa 1900: Personnel, Funding, and Productivity of the Academic Establishments," *HSPS* 5 (1975): 1–185.

4. Robert H. Silliman, "Fresnel and the Emergence of Physics as a Discipline," *HSPS* 4 (1974): 137–62; Yehuda Elkana, "Helmholtz' 'Kraft': An Illustration of Concepts in Flux," *HSPS* 2 (1970): 263–98.

5. David Kaiser and W. Patrick McCray, eds., *Groovy Science: Knowledge, Innovation, and American Counterculture* (Chicago: University of Chicago Press, 2016).

6. David Cahan, "Werner Siemens and the Origin of the Physikalisch-Technische Reichsanstalt, 1872–1887," *HSPS* 12, no. 2 (1982): 253–83; Lillian Hoddeson, "The Discovery of the Point-Contact Transistor," *HSPS* 12, no. 1 (1981): 41–76; Barton J. Bernstein, "In the Matter of J. Robert Oppenheimer," *HSPS* 12, no. 2 (1982): 195–252; Arturo Russo, "Fundamental Research at Bell Laboratories: The Discovery of Electron Diffraction," *HSPS* 12, no. 1 (1981): 117–60; Lewis Pyenson, "Audacious Enterprise: The Einsteins and Electrotechnology in Late Nineteenth-Century Munich," *HSPS* 12, no. 2 (1982): 373–92.

appropriates the language of "discovery" (i.e., science) for a history of one of the world's great industrial laboratories (Bell Labs) and the invention (i.e., technology) with which it is most famously associated. But Hoddeson was not alone in helping Volume 12 break the mold. From that point on, a trickle of articles appeared through the rest of the '80s on the history of the earth sciences, nuclear reactors and bombs, industrial research, and the interplay of solid-state research with technologies such as the laser and transistor.[7]

Why did the tide suddenly turn in 1981 (with some articles likely written the previous year)? I do not have a comprehensive answer, but it is important to note that some do. Elsewhere in this special issue David Kaiser and Julia Menzel discuss "Forman 1 and 2," Paul Forman's groundbreaking theses about the twentieth-century physical sciences published in this journal. But there is also a Forman 3, which appeared in *History and Technology* in 2007.[8] There, Forman makes the claim that Western culture valued science above technology until an abrupt shift in 1980, and that historians of technology have been blind to this shift because of their preoccupation with showing the autonomy of engineering and technology from science. Forman is not alone in describing an "epochal break" in conceptions of the relationship between science and technology that took place in or about 1980.[9] A series of important events in the evolving relationship between science and technology did indeed happen that year: the election of Ronald Reagan, the initial public offering of Genentech, the Bayh-Dole Act, the *Diamond v. Chakrabarty* decision. However, most features of the supposed epochal break (such as an increasing frequency of academic patenting and entrepreneurship), began in the second half of the 1960s.[10] I have argued elsewhere that it is far from a coincidence that this shift

7. Allan A. Needell, "Nuclear Reactors and the Founding of Brookhaven National Laboratory," *HSPS* 14, no. 1 (1983): 93–122; Judith R. Goodstein, "Waves in the Earth: Seismology Comes to Southern California," *HSPS* 14, no. 2 (1984): 201–30; Willem D. Hackmann, "Sonar Research and Naval Warfare 1914–1954: A Case Study of a Twentieth-Century Establishment Science," *HSPS* 16, no. 1 (1986): 83–110; Arturo Russo, "Science and Industry in Italy between the Two World Wars," *HSPS* 16, no. 2 (1986): 281–320; Robert W. Seidel, "From Glow to Flow: A History of Military Laser Research and Development," *HSPS* 18, no. 1 (1987): 111–47.

8. Paul Forman, "The Primacy of Science in Modernity, of Technology in Postmodernity, and of Ideology in the History of Technology," *History and Technology* 23, no. 1/2 (2007): 1–152.

9. Alfred Nordmann, Hans Radder, and Gregor Schiemann, eds., *Science Transformed?: Debating Claims of an Epochal Break* (Pittsburgh: University of Pittsburgh Press, 2011).

10. Paula Stephan, *How Economics Shapes Science* (Cambridge, MA: Harvard University Press, 2015); David C. Mowery, Richard R. Nelson, Bhaven N. Sampat, and Arvids A. Ziedonis, *Ivory Tower and Industrial Innovation: University-Industry Technology Transfer Before and After the Bayh-Dole Act* (Stanford, CA: Stanford University Press, 2015).

started at the same time as the protests and calls for scientific reform of the late 1960s.[11]

Even if Forman 3 is an overly schematic rendition of the "real" world, it would be a perfectly plausible argument if it applied only to the closed, artificial world of *Historical Studies in the Physical Sciences*. Volumes 1–11 (1969–1980) showed science triumphant, with no hint of technology or protest or challenge to the disciplines and their authority; then suddenly in Volume 12 (1981) the system broke down and afterward technology became ubiquitous. Today, the articles in *Historical Studies in the Natural Sciences* pertain to precisely the post-1980 world that Forman 3 laments. Interdisciplinarity, technology, and wider societal involvement in and critique of science are central to most of the articles the journal publishes today. One possible conundrum remaining, even for Forman 3 in its restricted application to this journal, is that the majority of those articles examine science before his posited epochal break and therefore undermine the argument that the pursuit of knowledge changed abruptly in that year. I suspect Forman would reply that today's historians inhabit a post-1980 world and therefore cannot help but see its features anachronistically imprinted on earlier times.

HISTORICAL STUDIES IN THE ENGINEERING AND APPLIED SCIENCES?

Maybe Forman would be right about that! My own view is that Forman 3 and related authors such as Philip Mirowski, Hans Radder, and Alfred Nordmann diagnose real shifts in how science was funded, valued, and conducted, and that *HSNS* should document those shifts while also placing them in a longer historical context that complicates the narrative of an abrupt epochal break. Indeed, Hyungsub Choi and I attempted to do just that in the pages of this journal.[12] But I also think the pre-1980 science that Forman 3 mourns never really existed. The "physical sciences," and even more so the "natural sciences," have never operated entirely only on their own terms, even with respect to the

11. Cyrus C. M. Mody and Andrew J. Nelson, "'A Towering Virtue of Necessity': Interdisciplinarity and the Rise of Computer Music at Vietnam-Era Stanford," *Osiris* 28, no. 1 (2013): 254–77.

12. Cyrus C. M. Mody and Hyungsub Choi, "From Materials Science to Nanotechnology: Interdisciplinary Center Programs at Cornell University, 1960–2000," *HSNS* 43, no. 2 (2013): 121–61.

knowledge they produce. David Hounshell has shown that Forman 3's picture of pure and triumphant pre-1980 science was prompted by physical scientists' fear that inventors and engineers were winning in the courts and in public opinion, rather than reflecting widespread respect for the primacy of unsullied knowledge-making.[13] Indeed, some of the most vocal champions of pure science were frustrated that they themselves had not been able to cash in on their knowledge-making!

Adopting a more heterogeneous picture of science does not mean we should disown this journal's first eleven volumes. But the world has changed since then, and the facets of science that interest historians have shifted in tandem. One major change is that the interdisciplinary field of Science and Technology Studies (STS) was just emerging in the 1970s, whereas many of the journal's authors today were trained in and/or are employed by STS programs (myself included on both counts). History has always had an important place in STS, though in the early days historically minded STS was usually practiced by people who would have described their approach as Sociology of Scientific Knowledge (SSK), and few of those who published in *Historical Studies in the Physical Sciences* would have said at the time that they were doing either STS or SSK.[14]

Today, some of the key stances of SSK and STS are still controversial among some *HSNS* authors: methodological and especially epistemic relativism, a social constructivist view of scientific knowledge, skepticism toward facts and scientific expertise more generally. Yet if we bracket epistemology and just look at what people write, the journal today is suffused with the aims of STS: to show that science and scientists are seamlessly part of society, that science is a heterogeneous enterprise that co-evolves with—or is even "co-produced" with—plenty of other heterogeneous enterprises, that scientific knowledge-making is always done in conjunction with other activities that do not have making scientific knowledge as their aim.[15]

My view, then, is that there is so much more engineering and technology in *HSNS* than there was in *HSPS* not so much due to the ascendance of post-1980

13. David A. Hounshell, "Edison and the Pure Science Ideal in 19th-Century America," *Science* 207, no. 4431 (1980): 612–17.

14. Steven Shapin, "Phrenological Knowledge and the Social Structure of Early Nineteenth-Century Edinburgh," *Annals of Science* 32, no. 3 (1975): 219–14; Donald MacKenzie, "Statistical Theory and Social Interests: A Case-Study," *Social Studies of Science* 8, no. 1 (1978): 35–83.

15. Sheila Jasanoff, *States of Knowledge: The Co-Production of Science and the Social Order* (London: Routledge, 2004).

technoscience, but rather because the axioms of STS and SSK are now a kind of diffuse background for most *HSNS* articles. The two are related, of course. STS is, after all, science *and technology* studies, and one of its practitioners' favorite categories is "technoscience"—both symptoms of the post-1980 condition that Forman 3 diagnoses. I would like to see more work—published in *HSNS* and elsewhere—historicizing STS's sometimes ahistorical view of what counts as "science" and "technology."[16] But STS is interested in *all* of the places where science is most entangled with some wider world (or, in a constructivist sense, the places where that contingent wider world exerts some influence and therefore makes scientific knowledge also contingent). Technology is one of those points of contact. If you look across the journal's current offerings, you can find many more: environmentalism, nationalism, colonialism, education, bureaucratic administration, among others.[17]

Given the journal's current orientation to science's heterogeneities, it is no surprise that the engineering sciences are a frequent topic, since heterogeneity is one of the defining characteristics of the engineering sciences. That is not to say that those scientists who describe their work as "fundamental" or "basic" and who profess no interest in application or technology do not in fact have brands in lots of different fires. Nor am I subscribing to a linear model that pictures knowledge moving from fundamental research to applied science to product development to technology-in-use, with the engineering scientist at the tipping point mediating between science and society.[18] Rather, I see the engineering and applied sciences as fields where *potentialities* are necessarily diverse, and therefore where science's heterogeneity is at the surface. The people who occupy the engineering sciences are usually either on their way to or from other domains, or their positions require them to coordinate with

16. For a helpful critique of STS's ahistorical view of science (but also a good example of the 1980 epochal break genre), see Philip Mirowski and Esther-Mirjam Sent, "The Commercialization of Science and the Response of STS," in *The Handbook of Science and Technology Studies*, 3rd ed., ed. Edward J. Hackett, Olga Amsterdamska, Michael Lynch, and Judy Wajcman (Cambridge, MA: MIT Press, 2008), 635–90.

17. Gabriel Henderson, "Adhering to the 'Flashing Yellow Light': Heuristics of Moderation and Carbon Dioxide Politics during the 1970s," *HSNS* 49, no. 4 (2019): 384–419; Michelle D. Hoffman, "Just a Theory: The Atomic Theory Debate and High School Chemistry, 1905–1917," *HSNS* 47, no. 4 (2017): 494–528; Leandra Swanner, "Instruments of Science or Conquest? Neocolonialism and Modern American Astronomy," *HSNS* 47, no. 3 (2017): 293–319.

18. David Edgerton, *The Shock of the Old: Technology and Global History since 1900* (London: Profile Books, 2006) spotlights technology-in-use.

other domains. If we want to tell stories about how science intersects with other domains, well, the engineering sciences are a fruitful place to look.

For example, researchers can start out in the engineering sciences, working with a clear technological outcome in mind, yet their discoveries are praised for their fundamental character: consider Shuji Nakamura and Jack Kilby, physics laureates whose only degrees were in engineering. Conversely, I have interviewed several people whose degrees were in physics but whose job titles contained the words "engineer" or "applications" (sometimes, indeed, "applications engineer"). Such people necessarily learn to manage complex networks of vendors, customers, regulators, technicians, public relations people, professional societies, etc. Meanwhile, the organizations most closely associated with the engineering sciences, such as industrial laboratories or the U.S. National Labs system, know that variety is good strategy for keeping their staff happy and the organization abreast of developments. One of my favorite examples is Richard Garwin, the IBM physicist who pops up as an important player in the histories of several fields, including nuclear weapons design, gravitational radiation research, anti-ballistic missile defense, Vietnam-era counterinsurgency, and superconducting computing.[19]

A journal dedicated to the history of science-as-part-of-society is just more likely to include such figures (or include them in a wider array of their various guises) than one dedicated to historical studies in the physical-sciences-full-stop. Does that mean we should change the journal's name again? That is, if we are not publishing historical studies in the natural-sciences-full-stop either, then perhaps the title should reflect that? I don't think so. My reason is that the journal has not yet provided an answer to the question posed by the late, great Ann Johnson in its pages: "What if we wrote the history of science from the perspective of applied science?"[20]

Perhaps that sounds like a contradiction. After all, up to this point I have argued that *HSNS* authors have become quite good at writing histories of

19. Some of Garwin's avatars appear in Rebecca Slayton, *Arguments That Count: Physics, Computing, and Missile Defense, 1949–2012* (Cambridge, MA: MIT Press, 2013); Harry Collins, *Gravity's Shadow: The Search for Gravitational Waves* (Chicago: University of Chicago Press, 2010); and Cyrus C. M. Mody, *The Long Arm of Moore's Law: Microelectronics and American Science* (Cambridge, MA: MIT Press, 2017). For a popular biography, see Joel N. Shurkin, *True Genius: The Life and Work of Richard Garwin, the Most Influential Scientist You've Never Heard Of* (Amherst, NY: Prometheus Books, 2017).

20. Ann Johnson, "What If We Wrote the History of Science from the Perspective of Applied Science?," *HSNS* 38, no. 4 (2008): 610–20.

science that include applied science. Indeed, in this journal the engineering and applied sciences now have gravitas in their own right; they are no longer treated as epiphenomenal to the natural sciences. Take, for instance, Kendrick Oliver's recent article on the cosmic background radiation, which places the U.S. telecom monopoly at the center of the action.[21] It is difficult to imagine such an article appearing in the first eleven volumes of this journal. But we are still quite far from publishing articles where the arrow is fully reversed: that is, studies where the natural sciences are treated as epiphenomenal to the engineering and applied sciences. That was, I think, what Ann had in mind, at least as a polemical position: she liked nothing better than stories where industrial researchers tossed out fundamental discoveries that stymied their academic colleagues.[22]

Perhaps a journal that answers Ann's question—*Historical Studies in the Engineering and Applied Sciences*?—will come about someday. Or not. The people who would publish there are not yet numerous enough to sustain their own journal, and in the meantime they are not exactly homeless. *HSNS* has been a wonderful host for some of us, and hiving off to a more specialized journal would rob us of much of the energy and liveliness that accompanies this journal's very broad construal of the "natural sciences."

Yes, the natural sciences are still at the journal's core—there is still a red thread that connects back to the journal's beginning and not just to Volume 12 onward. Today, however, the journal's background assumption is that the natural sciences take place within heterogeneous societies and are themselves in large part heterogeneous and outward-looking. Understanding the natural sciences therefore requires attending to the ways scientists participate in activities and communities that are not strictly scientific. If you can make a case that your study contributes to understanding science as more-than-science, then the journal's editors will examine your case on its merits—even if the science in question is not "natural" but rather social, engineering, agricultural, biomedical, etc.

21. Kendrick Oliver, "'The Lucky Start Toward Today's Cosmology'? Serendipity, the 'Big Bang' Theory, and the Science of Radio Noise in Cold War America," *HSNS* 49, no. 2 (2019): 151–93.

22. Ann Johnson, "How Ford Invented the SQUID," *IEEE Spectrum* 51, no. 11 (2014): 40–61.