Projecting the Future? The Shifting Boundaries of Postwar American Science
Biomedical Computing: Digitizing Life in the United StatesInstrumental Community: Probe Microscopy and the Path to NanotechnologyGenentech: Beginnings of BiotechThe Visioneers: How a Group of Elite Scientists Pursued Space Colonies, Nanotechnologies, and a Limitless Future by Joseph A. November; Cyrus C. M. Mody; Sally Smith Hughes; W. Patrick Mccray
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# Projecting the Future? The Shifting Boundaries of Postwar American Science

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Joseph A. November. *Biomedical Computing: Digitizing Life in the United States*. Baltimore, MD: Johns Hopkins University Press, 2012. ix + 344 pp. ISBN: 978-1-421-40468-4. $60.00 (hardcover).

Cyrus C. M. Mody. *Instrumental Community: Probe Microscopy and the Path to Nanotechnology.* Cambridge, MA: MIT Press, 2011. 256 pp. ISBN: 978-0-262-13494-1. $36.00 (hardcover).

Sally Smith Hughes. *Genentech: Beginnings of Biotech*. Chicago: University of Chicago Press, 2011. xv + 213 pp. ISBN: 978-0-226-35918-2. $25.00 (hardcover).

W. Patrick Mccray. *The Visioneers: How a Group of Elite Scientists Pursued Space Colonies, Nanotechnologies, and a Limitless Future*. Princeton, NJ: Princeton University Press, 2012. 366 pp. ISBN: 978-0-691-13983-8. $29.95 (hardcover).

In December 1959, physicist Richard Feynman delivered a lecture with the flavor of a manifesto, titled "There's Plenty of Room at the Bottom," which is now considered an event formative to the nascent field of nanotechnology. Feynman speculated about the possibility of one day approaching matter at the level of the individual atom, thereby allowing for dramatic gains in the ability to perform chemical manipulation, as well as a corresponding leap in the ability to visualize new compounds. Feynman concluded by posing two challenges, each backed by a thousand-dollar incentive. The first called for the construction of a tiny motor, and the second required an act of textual

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reproduction at a greatly reduced scale. As we recall Feynman's challenge early in the twenty-first century, it is useful to remember how radical his proposals would likely have seemed to his audience. Equally, his words reflected the largely unchallenged technological optimism of the period, invoking a postwar atmosphere when critiques of science, while emerging, still had to contend with the growing dominance of American science across numerous fields, with generous sources of funding from a range of Cold War institutions.

The venue for Feynman's talk, Caltech, was itself in the midst of rapid transformation, and Feynman had been recruited away from Cornell University scarcely a decade earlier. Along with his close colleague, frequent interlocutor, and sometimes antagonist, Murray Gell-Mann, Feynman would make Caltech one of the leading centers for American physics. Nearby, the University of California system also achieved some approximation of Clark Kerr's ambitious vision for the "multiversity."[1] It was a moment in the history of science when both the biological and the physical sciences pursued new research agendas at an early point in the post–World War II era.[2] Subsequent decades would witness the gradual erosion of the confidence and sources of funding underlying this vision, dramatically transforming the mechanisms of knowledge production.[3]

This transformation of the university, and with it, the practice of science, is a theme common to all four titles under review here. The subsequent turn toward privatization and capitalization was by no means part of a conscious strategy, but instead emerged as the unexpected outcome of a series of intersecting developments. Among these were the availability of greater computing power, allowing the ability to model and handle significantly larger amounts of data; the appearance of newer and more sophisticated technologies of visualization; and the emergence of new legal frameworks permitting the commercialization of life forms. By 1980, many Americans' research agendas continued to rely heavily upon the existing federal research economy as one possible

1. Clark Kerr, *The Uses of the University* (Cambridge, MA: Harvard University Press, 1963).

2. Peter Westwick, ed., *Blue Sky Metropolis: The Aerospace Century in Southern California* (Berkeley: University of California Press, 2012). See also Westwick's earlier work on the national lab system, and on the role of the Jet Propulsion Laboratory in the American space program: *Into the Black: JPL and the American Space Program, 1976–2004* (New Haven, CT: Yale University Press, 2006); George Dyson, *Project Orion: The True Story of the Atomic Spaceship* (New York: Henry Holt, 2002).

3. Roger Geiger, *Research and Relevant Knowledge: American Research Universities since World War II* (New Brunswick, NJ: Transaction, 2004).

model, yet the opportunity to explore other options through private funding had become a distinct possibility.

Joseph November's *Biomedical Computing* begins by appealing to discontinuity, asking readers to note the lack of a necessary relationship between computers and biology, despite the recent trend toward the "convergence of information technology and the study of life" (1), a development with its origins dating to the immediate postwar. For November, this reminder allows him to take up what he characterizes as the "unexpected computerization of the study of life" (6), a story that follows his actors to two continents, as well as a range of institutional settings. Some of these may already be familiar, such as National Institutes of Health (NIH), Stanford University, and the related work of figures such as Joshua Lederberg. It is this sense of familiarity against which the author pushes the most strenuously, asking us to set aside a conventional understanding of computers as motivated exclusively by DARPA (Defense Advanced Research Projects Administration) and its subsequent impact upon the development of computer networks, as well as personal computing. Instead of this type of reduced narrative, November seeks to bring in contingency as motivated by wartime concerns. In return, he offers us a story that starts with a few of the expected names referenced in passing—Vannevar Bush, J. Presper Eckhart—while shifting the focus in a very different direction, seeking to illustrate how the historical and material relationship between seemingly disparate fields might converge.

Framing his story as a parallel Anglo-American project, November starts with Operations Research (OR) in wartime Britain. A field associated with wartime necessity, OR made possible the best use of resources in decision making, with a famous example being the use of convoys in shipping to reduce Allied supply losses. November traces this new field and its impact upon the development of radar to the work of x-ray crystallographers in postwar Britain, particularly those based at Cambridge University. The sheer number of calculations necessary to generate models of the complex molecules under study made for a ready transition from human "computers" to early versions of the electronic digital computer, and November focuses on EDSAC (Electronic Delay Storage Automatic Calculator) and its use by John Kendrew. With this type of fine detail at hand, November is meticulous and exacting in his account, laying out the material and methodological transformations made possible through the transition to digital computing. This is true of November's handling of both biological work and computing practice. The two fields are carefully brought together, with November establishing a mutually dependent relationship between them and emphasizing that computing practice would undergo reciprocal change as part of its incorporation within a laboratory environment.

November seeks to incorporate this style of mini-case study throughout his narrative, showing "how the demands of biological and medical research shaped computer design" (15). Challenging a narrative in which computers arrive relatively late on the scene, only after having evolved sufficient capacity and speed to handle the data relevant to the study of complex living systems, he offers instead a relationship of interdependency, a contingent series of developments in which new tools and research questions interact with each other. At the same time, this is not a hagiographic account, and November frequently calls into question the increasing reliance of large institutions upon biological computing as a means to an end, noting that the sums devoted by NIH, for example, to such pursuits have yet to fully realize the results claimed by proponents.[4] He is keen to disavow the semblance of any "necessary" relationship with computers, challenging a popular narrative mobilized through such successful and highly visible efforts as the Human Genome Project (HGP).

Cyrus Mody's *Instrumental Community*, similarly motivated by the rapid growth of new fields and emerging dynamics of knowledge production, explicitly brackets its material object and focuses instead on the diverse human communities that develop around a given set of new technologies. Mody's interest lies in the development of the scanning tunneling microscope (STM), which has occupied a prominent place in narratives of recent history of technology, granting it a privileged position as the driving force behind much of nanotechnology. For Mody, the issue is not so much the underlying set of assumptions affirming the centrality of the STM to nanotech—although he does hint at the possibility for critique—but rather the failure to provide sufficient explanatory mechanisms for the dynamics of change: "nanotechnology's proponents and analysts have not explained how these microscopes made this field possible" (5). His proposed alternative, offering a rich descriptive account of the users and their ability to employ an instrument in a range of new ways, echoes November's remarks concerning the computer, but he adds a much greater emphasis on the end-user.

The title of Mody's work stands in as a frame for its major concerns, namely the ability to employ a new technological object in ways that build up new resources and networks, and also emphasizes the role of pragmatics, or actors

4. Francis Collins, *The Language of Life: DNA and the Revolution in Personalized Medicine* (New York: Harper Collins, 2010).

"doing things that would propagate beyond their laboratories and change the world" (6).[5] The latter reflects Mody's concern with tracking the movement, at least potentially, from bench-top experiment to subsequent applications within an industrial setting, bringing together existing literatures. In part, this move to embrace human agency represents an STS gesture toward the need to better understand technology in its social context, but Mody brings the ethnographic to bear on the problem of doing recent history as well, aware that many of his actors remain active participants in an evolving field. This hybrid approach to the dynamics of change, combined with an impressive wealth of oral history interviews, becomes a conspicuous source of strength. Mody's extensive source materials, archival and ethnographic, will appeal to a broad range of scholars.

With this framework in hand, Mody's story proves a compelling and engaging one, taking us through the dynamics shaping the formation of new communities around the technology, even as the object itself undergoes change. He traces these communities first at major corporate labs, such as IBM and Bell, and in subsequent chapters he turns to transnational networks such as those linking actors between Zurich and California. Along with his emphasis on the social dimension, Mody explicitly engages with questions of the academy and its relationship to the market, and his discussion of commercialization nicely complicates any neat distinctions tied to the passage of the Bayh-Dole Act in 1980. On this point specifically, he notes that "commercialization," if defined simply as "the conversion of professors' knowledge into marketable products" (127), should lead to the recognition that there was "no point at which academic probe microscopists weren't [already] involved in such activities" (127). In other words, the "break point" year (1980) celebrated in many accounts means something subtly different for Mody, not the beginning of commercialization per se, but instead, the commercialization of "activities that were already ongoing" (125). This observation represents a challenge to periodization and affirms the significance of Mody's major claim about the critical role of technological communities, which take precedence over legal and administrative changes.

Sally Smith Hughes's *Genentech*, the story of Stanley Cohen, Herbert Boyer, Paul Berg, and the transformative potential of recombinant DNA technology as

5. Sarah Kaplan and Joanna Radin, "Bounding an Emerging Technology: Para-Scientific Media and the Drexler-Smalley Debate about Nanotechnology," *Social Studies of Science* 41, no. 4 (2011): 457–85.

a commercial entity, approaches this same cluster of issues surrounding commercialization in the life sciences.[6] If portions of this story are somewhat familiar through the awarding of the Nobel Prize to Berg (1980), Hughes provides numerous insights in generating a different version of the story, one that concentrates on the formation of Boyer's commercial venture, Genentech, founded in 1976 in conjunction with venture capitalist Robert Swanson. As with the other works discussed here, we might note a recurring California theme—encompassing Stanford (November), the University of California–Santa Barbara (Mody), and here, the University of California–San Francisco and Stanford once more (Hughes)—leaving ample room to consider the unique constellation of cultural, geographical, and legal factors that made for such a productive collaborative environment on the coast.

Hughes is less concerned with telling a specifically geographic and regional story, instead exploring the numerous possibilities made available through commercialization and the newer legal frameworks emerging in the late 1970s. Even before Bayh-Dole, we again have scientists recognizing the potential of their work in the marketplace, and if Hughes is less interested than Mody in questioning standard accounts of scientific commercialization, neither is her version a strictly teleological one. It too appears more contingent than designed, with Hughes frequently mobilizing the language of the individual personality and corresponding scientific style. Published as part of a Chemical Heritage Foundation (CHF) series, Hughes's work borrows many of the trappings of business history, narrating the history of a single firm, and in this sense it proves a bit more conventional than the other works referred to here. At the same time, the account is fast-paced and lively, and the major actors are depicted not as heroic entrepreneurs but as actors at the intersection of a particular research and legal climate, one that Boyer and Swanson happened to be among the first to explore. For Hughes, the scientific and work habits associated with her actors figure most prominently, and she observes that Boyer and Cohen accomplished what they did through the conjoined potential of their "personality and professional commitments" (1).

Although all four of these works address the immediate future, W. Patrick McCray's *The Visioneers* by far does so the most explicitly, with his title offering a neologism combining the twin notions of "engineers" with "visionaries," those with the ability and willingness to map out the future. His major

6. Doogab Yi, *The Recombinant University: Genetic Engineering and the Emergence of Biotechnology at Stanford, 1959–1980* (PhD dissertation, Princeton University, 2008).

actors trace out fields situated at the very limits of scientific possibility, and the boundaries of knowledge do not mark the only form of constraint. McCray starts us off in the mid-1970s, referencing California Governor Jerry Brown in his introduction, capturing an era when politicians might still dare to admonish their constituents about the need for restraint. Of the two major figures driving the work, Gerard O'Neill looks to space and the prospect of resettlement as the best option for extending and improving human existence, using his post at Princeton University as a platform to disseminate his ideas. The second figure, Eric Drexler, an MIT-trained engineer and advocate of more radical forms of intervention, offers a vision that would become at least one narrative version of the emerging field of nanotechnology, a startling world outlined in his seminal 1986 work *Engines of Creation*.

Juxtaposing these two figures, McCray posits an American future in which the utmost limits of outer and interior space serve as contrasting realms of exploration, with both still grounded in the most recent science. In this respect, *The Visioneers* is the most politically conscious of the accounts featured here, with considerable attention devoted not just to the science, but also to the weighted choices and consequences informing its making. Along these lines, the work proceeds to tackle related issues of public reception. For example, McCray examines the foundation, dissemination, and consumption of new ideas through the magazine *Omni*, a Bob Guccione vehicle in which "soft" scientific content would meet lifestyle aspirations, making it an ideal site for ambitious content. With this chapter and others like it, it is clear that McCray is having great fun with his material, and the narrative remains serious in it intent, even as it embraces the colorful characters and schemes that would liven up this era of apparent deprivation.

If the word "limit" refers to Governor Brown, it also connotes the Club of Rome and its influential report concerning "The Limits to Growth" (1972), a study of the implications for population and economic growth under circumstances of highly constrained or finite resource supplies.[7] This explains in turn the motivation behind the choice of figures such as O'Neill and Drexler, who represent solutions like space colonization or developing more resources from the existing supply of materials. To put it crudely, they believed the limits could be overcome either by escaping the earth or by making more stuff. McCray is perhaps at his most interesting in exploring the limits of "normal"

7. Matthew Connelly, *Fatal Misconception: The Struggle to Control World Population* (Cambridge, MA: Belknap Press of Harvard University Press, 2008).

science, tracking his actors and their ambitions to the point where many of the ideas were taken up and appropriated by others. Here, the "normal" meets the edge of the "fringe," and if McCray seeks to preserve some notion of the original vision, he nonetheless acknowledges the blurred quality that followed, with scientific schemes meeting popular culture in a hybrid fusion.[8]

Together, these four works offer a future that is surprisingly modest in scale, considering the heady ambitions of slightly more than fifty years ago, when the postwar American state appeared more than willing to fund almost any promising venture.[9] If the limits imposed prove to be distinct from those of McCray's mid-1970s moment of privation, these are genuine limits, nonetheless, constraints revealed by the structural patterns informing newer ways of "doing science." At the same time, there is a story of elision here, too, with science moving the discussion away from the material realities of work and labor, replacing these categories with the prospect of deferred possibility. For November, that possibility has yet to be fulfilled, and the computing gambit represents a seductive style of path dependency, leading many major decision-makers to double-down on the power of data and modeling. Mody's story concerns itself less with a derivation of nanotech's origins per se, and offers instead the flexibility of a new field and its rich possibilities, one with sufficient malleability to appeal to a wide range of actors, with nanotechnology thereby meeting more than one set of communal needs.

Hughes provides an account of one successful firm, but makes no claims for its applicability as a general case, looking instead at the unusual circumstances allowing Genentech to become a reality. If McCray ultimately returns us to the sober language of choice and "making" a future, he recognizes, like Mody, that the field of nanotechnology holds a great number of possible narratives within it. The Drexler narrative thus stands as just one among the many, and by the end of *The Visioneers*, that story has been matched and even surpassed by some of the competing alternatives. In all four accounts, then, the immediate future proves far less bountiful than it might once have, and the shifting uncertainties associated with new ways of practice have yet to settle into a clear and coherent vision. It is also worth noting that this constrained future has appeared at

8. Michael Gordin, *The Pseudoscience Wars: Immanuel Velikovsky and the Birth of the Modern Fringe* (Chicago: University of Chicago Press, 2012).

9. Audra Wolfe, *Competing with the Soviets: Science, the State and Technology in Cold War America* (Baltimore, MD: Johns Hopkins University Press, 2012); Stuart W. Leslie, *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford* (New York: Columbia University Press, 1994).

a present moment when the language of optimism has been adopted by many emerging economies with aspirations for rapid growth.[10] If the future here is not the radical one embraced by figures such as Hans Moravec and Ray Kurzweil, both of whom have appealed to the possibility of departing the physical body, it remains one in which such ideas continue to hold a place in the conversation, even while subject to numerous constraints: financial, material, and scientific.[11]

10. Aiwha Ong and Nancy Chen, eds., *Asian Biotech: Ethics and Communities of Fate* (Durham, NC: Duke University Press, 2010).

11. Hans Moravec, *Mind Children: The Future of Robot and Human Intelligence* (Cambridge, MA: Harvard University Press, 1990); Raymond Kurzweil, *The Age of Intelligent Machines* (Cambridge, MA: MIT Press, 1990).