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Featured Review

Working at the Intersection of the Histories of Science, Technology, and Agriculture

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Evolution Made to Order: Plant Breeding and Technological Innovation in Twentieth-Century America. By Helen Anne Curry. Chicago: University of Chicago Press, 2016. 320 pp., hardback, $45.00, ISBN 978-0-226-39008-6.

Helen Anne Curry's book is a masterful examination of the attempts to apply the technologies of x-rays, the chemical mutagen colchicine, and nuclear radiation to plant breeding, in an effort to change the genetic make-up of plants so that their subsequent evolution could be "made to order." She also makes an important historiographical argument that entwines the histories of science, technology, and innovation which, given the significance of her subject matter, suggests a broad collaboration that can and should include agricultural historians.

Curry's historiographical argument concerns "a nested history of innovation … a history of innovations (in breeding techniques and technologies) whose primary purpose was to generate further innovations (in crops, trees, and flowers)" (7). Thus, she is interested in both techniques and their results, as well as the mutual interactions among them. She offers this approach rather than one focusing on innovators such as Luther Burbank and Norman Borlaug, or techniques such as double-cross hybrids. This dynamic perspective allows us to see these developments in plant breeding on their own terms as they developed rather than in terms of their results.

This history is thus embedded within "a broader history of American technology and innovation" (3). That is, these mutagens (x-rays, colchicine, nuclear radiation) were opportunistically and creatively applied to agriculture since their initial applications were in quite different fields. This story, then, is not simply a history of scientific ideas, technological advance, or agricultural practice; it is also about how something like genetic technologies "were completely entangled with other areas of innovation" (3).

If, as Edgar Anderson of the Missouri Botanical Garden put it in his 1952 book *Plants, Man, and Life*, "Knowledge is all of one piece but universities (by tradition and for budgetary reasons) are divided into departments," then historians—whether we identify as agricultural historians or as students of the history of science or technology—will benefit from such a broad and synthetic perspective.[1] Her approach also has obvious implications for how we view current developments in biotechnology, allowing us to assess their promise and results in this broad historical context.

Curry begins her examination with an image from a 1932 *Popular Science Monthly* article, titled "Use X-Ray to Get a Better Corn Crop." The image caption states:

> Trundling an X-ray machine on wheels up and down the rows of an experimental garden, Dr. L. J. Stadler, of the Missouri College of Agriculture, is seeking to produce new species of farm crops by subjecting his plants to treatment by the invisible rays. Strange alterations take place in corn and other growing plants when they are bombarded by X-rays, laboratory tests have previously shown. Dr. Stadler expects improved varieties to result from this practical experiment. His portable apparatus receives electric current by a long cable (2).

It is an appropriate introduction to many threads of her story. X-rays clearly were not designed for this purpose and, indeed, the picture of Stadler and his machine (long cable not visible) is quaint, let's say. Yet the enthusiasm—his and *Popular Science Monthly*'s—is evident. An exotic technology's "invisible rays" bombard plants just as they do broken limbs. Besides giving us images of the latter, they carry the potential to induce new plant varieties.

Scientists such as Stadler combined findings from genetics—especially on the structure of chromosomes and mutations from T. H. Morgan's fruit-fly laboratory at Columbia University—with adaptations of exciting technology. Throughout the book, Curry gives succinct and effective summaries of the relevant science to lay readers with a strong working knowledge of the theories and experimental results of such key figures as Gregor Mendel, Hugo deVries, Luther Burbank, Albert Blakeslee, Morgan, and Stadler. She ably explains concepts such as polyploidy and clearly conveys the importance of work at such key research sites as Cold Spring Harbor and Brookhaven National Laboratory.

Stadler's scholarly writing was properly restrained and as prone to the passive voice as other scientists, but informed scientific journalists in *Popular Science Monthly* and other outlets could be more enthusiastic. Curry deftly monitors such opinion and incorporates it into her story because she recognizes that this work was not simply done by elite scientists as so-called pure research. The work mattered widely and was taken up not just at state

1. Edgar Anderson, *Plants, Man, and Life* (Boston: Little, Brown, and Company, 1952), 110.

agricultural stations but by individual farmers and gardeners who were fascinated by and excited for these innovations. A later discussion of Burpee Seed Company's commercial innovation in marketing "Atomic Seeds" and their use of customers' enthusiasms to find wanted varieties reflects the important popular dimension to this work.

Like x-rays, nuclear fission was clearly designed for a drastically different and less benign purpose, despite whatever "Atoms for Peace" rationalizations were offered after the fact. Its application to agriculture as a way to induce mutations is another example of innovation in biotechnology being embedded in the broader sweep of more general technological advances. Having unleashed atomic fission for military purposes, scientists could then explore peaceful applications like plant breeding.

The use of colchicine as a chemical mutagen to alter plant chromosomes is more closely tied to developments in agricultural chemistry, especially in fertilizers. As with fission and x-rays, it could speed up the process of mutations in seeds that could then be selected for by plant breeders. But again, even this example drives home that biotechnology has never unfolded in a vacuum nor as a primary end of its underlying research. Agricultural chemists appropriately looked for broad applications for their findings, ranging widely from their primary, intended purpose.

Curry makes a parallel point by noting the agricultural impulse to improve crops as a concomitant effort to improve farming as an industry. She points out the uncertainties of agriculture in the 1920s—falling prices and shrinking demand leading to cycles of overproduction. In that period, evolution made to order via x-rays held the promise to make agriculture a successful industry as useful food and nonfood crops could be produced with increasing market efficiencies. Thus, not only was agricultural technology embedded in the broader context of technological development, but agriculture itself could not be separated from the wider economy.

But just as that wider economy was a few short years away from collapsing during the Great Depression, the story of biotechnology is also, in Curry's telling, not one of cumulative and linear development. The hype and hope of these technologies, most clearly expressed by science journalists but often privately shared by the scientists themselves, was never realized. Evolution has never been "made to order" and, by monitoring the hype, Curry keeps a clear eye on the actual results of these research programs. But she does not want to see these efforts as "failures" either. Though they did not revolutionize agriculture, they nonetheless contributed new plant varieties and yielded theoretical insights.

Curry recognizes that x-rays, colchicine, and atomic energy, while sharing the same goal of crop improvement, are not ultimately connected either technically or conceptually. That is, they were three different technologies with separate histories, and they approached the task of inducing mutations on different conceptual bases. While they built on the common developing understanding of genetics and mutation, they contributed to a modern understanding of the "transgenic approach we evaluate today as having been successful" only incidentally and after the fact. They began as a series of innovations, practically minded if not always practical in result or activity (10). The biggest successes for the techniques Curry chronicles were with the red grapefruits Star Ruby and Rio Red, and the rice Calrose 76, which was valued for being short statured (211).

But other attempts now seem dangerously impractical. Brookhaven National Laboratory's gamma field experiment in the 1950s, for example, consisted of a piece of radioactive cobalt-60 placed atop a pole in the middle of the field, the idea being to test the impact of that radiation on a wide variety of food crops. Only for a few hours in the day, when the radioactive material was lowered into a lead-shielded compartment below ground, could Geiger-counter-wielding scientists like Seymour Shapiro enter the field. A photograph of the experiment area shows a barren field near the radiation source (142). Yet of course this seemed a reasonable exercise to Shapiro and his colleagues, and Burpee Seed Company's resulting atomic seeds were coveted by home gardeners seeking the largest and most beautiful flowers.

While Curry has a picture of a colchicine-altered turnip the size of the little girl holding it, her story is best exemplified by the application of these techniques to maize (127). Work on other crops and flowers established important concepts like the promise of seedless fruits from induced tetraploids (3x chromosome sets rather than the usual two of diploids), but improvements in a crop like maize would be significant given the global importance of cereal crops. That is why Stadler took his x-ray machine to the experimental corn plot, and why *Popular Science Monthly* publicized it in 1932. The results, however, were disappointing. While x-rays did induce mutations, Stadler came to view them as mostly deleterious. This mix of hype with disappointment over lackluster results is a recurring theme in Curry's book. Thus her point that it is more useful to study these innovations on their own terms rather than as the moment of conception of modern transgenic organisms.

Yes, these intertwined technologies reinforced and extended some basic genetic knowledge and this story tells us about how such innovations arise and develop. That they did not live up to their agricultural promise reveals something about the social contexts in which such science and innovation arise. If the influence on farming were greater, historians of agriculture would already be deep into telling an important and compelling story of wide interest.

That it has not had such influence, as Curry explores in her epilogue, has implications for evaluating modern claims for molecular biology. On the one hand, knowing how x-rays, chemical mutagens, and nuclear radiation have played out can temper excitement for this most recent way to make evolution to order. But that earlier story is also one of enthusiastic expectations by farmers, gardeners, and state agriculture extension agents, sometimes associated with land-grant universities. This context helps us understand current skepticism toward claims by the more privatized and profit-oriented science of today from consumers who see dystopian science fiction in x-ray machines among rows of corn and barren gamma fields.

Curry's work is important historiographically on several levels, as she asks historians of biology to incorporate the perspectives of not just the history of technology but also of the social processes of innovation (nuclear fission both for weapons and Atoms for Peace, for instance). Further, she resists viewing the story of innovation as either celebratory or elite. Though some familiar figures are present (Luther Burbank, Lewis Stadler, David Burpee), the interest and involvement of countless farmers and gardeners are also part of the story. Additionally, hers is not a story wherein each of these technologies is framed by their contribution to our existing understanding of genetic processes. Instead, she offers her readers an expansive, inclusive approach to how we can think about our various histories (of agriculture, biology, and technology) in richer, more integrated ways.

Finally, I welcome the many ways Curry's work suggests real opportunities for collaboration among rural historians, historians of agriculture, historians of science, and historians of technology. To take myself as an example, I am a historian of twentieth-century biology, particularly interested in the Missouri Botanical Garden's Edgar Anderson, who contributed both to the so-called Evolutionary Synthesis and to the study of maize. Anderson was a consultant to Pioneer Hi-Bred Corn Company, training such key researchers as William L. Brown, who became its president in 1975. Thus I have been interested, as my research subject was, in how genetic, cytological, and evolutionary knowledge can impact farming. I am equally appreciative of how agricultural practice can enrich and influence scientific knowledge. Colleagues working on the history of genetics are acutely aware of the role of land-grant colleges, agricultural stations, and such organizations as the American Breeders Association. We historians of science are interested in broadening our perspectives into conversation with such broader trends in history as climate, masculinities, digital humanities, global power knowledge, emotions, and many others through our journals *Isis* (see especially the regular "Focus" section) and the annual themed volumes in the *Osiris* series.

And I note parallel impulses among agricultural historians. In his 2010 article in this journal, "Reflections: Whither Agricultural History," David Danbom nicely traces the history of the Agricultural History Society and its evolution over the years from being predominantly USDA bureaucrats, to professional historians who largely grew up on farms, to those with interests in rural social history. He notes new contributions from "historians of diet, foodways, and food processing; urban-rural relationships and interactions; the transition to capitalism; and farmers as consumers" as enriching the field. He also points out the promise of environmental history as a sibling sub-discipline since agriculture "mostly takes place outside," and so the impact of the environment and environmental concerns on farming are direct and palpable.[2] Equally, the roundtable in this issue reflects this fruitful, deepening, and very welcome collaboration.

Helen Curry's book is another welcome contribution to a perspective both broader and more synthetic. It is an invitation to incorporate history of science and history of technology into agricultural history. If we can illuminate one another's scholarship as Curry has with her synthetic work, then we will all benefit.

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2. David Danbom, "Reflections: Whither Agricultural History," *Agricultural History* 84, no. 2 (Spring 2010): 166–75.