The Establishment of Agricultural Research

Agricultural Science and the Quest for Legitimacy. Farmers, Agricultural Colleges, and Experiment Stations, 1870–1890. ALAN I. MARCUS. Iowa State University Press, Ames, 1985. x, 269 pp. $22.50. Henry A. Wallace Series on Agricultural History and Rural Studies.

During the decades after 1870 the rise of big business and big government in the United States signaled the transformation of a mainly rural, localized society into the world's leading industrial and financial power. Among the changes that accompanied this transformation was a growing recognition of the importance of science. For its enthusiasts, "science" had more than one meaning, however, and varying interpretations given the idea produced conflict because each had direct and very different implications concerning resource allocation and expected results. In this book Alan I. Marcus deals with one instance of these conflicts, the conflict among farmers, agricultural schools, and agricultural scientists at the end of the 19th century.

By the 1870's, few doubted the need for scientific agriculture or the value of creating what became known as experiment stations. But as soon as anyone attempted to put this generally accepted idea into practice furious debate began. Scientists themselves divided on the value of field experiments. Some insisted that true scientific research required laboratory conditions where variables could be controlled and research replicated. Others argued that scientific research in agriculture could have little meaning unless it was conducted under real field conditions, with variables to be assessed by comparison of many field experiments under varying conditions.

Farmers disagreed with the scientists and among themselves as well. Most supported the advocates of fieldwork, but they divided over the meaning of scientific agriculture and therefore over what fieldwork should attempt to do. For some, science meant simply system; farmers should be taught the best means to conduct their business, and therefore fieldwork should be primarily demonstration. Others insisted that fieldwork be devoted primarily to testing scientific discoveries to determine which could be of practical use for the working farmer.

Still other disagreements surfaced in the debates over laboratory versus field and science versus system. Many farmers distrusted the new agricultural colleges, which they felt should teach young people how to be successful farmers but instead were teaching science, conducting experiments, and, worse, providing an academic education. Many agricultural college professors, on the other hand, although willing to drop many elements of a classical education, defended their programs as the only means to advance agriculture and insisted that future farmers could learn practical farming techniques on the job. State agricultural societies, state departments or bureaus of agriculture, boards of trustees of the agricultural colleges, and members of legislatures representing farming constituents regularly disagreed among themselves on program, emphasis, expenditures, and facilities location. When many states established the office of state chemist with the primary responsibility of testing and evaluating fertilizers, the chemists themselves could not agree on uniform testing and evaluation procedures, causing fertilizer producers, often with their own chemist authorities, to complain of unfair treatment and seek redress from the legislatures.

Conflicts inevitably became political, and the disputants—as many other groups were coming to do—recognized the importance of organization to advance their causes. Many were already organized; others created a variety of new organizations to increase their political influence. Although initially the various factions concentrated their attention on individual states, they increasingly looked to the national government, seeking reform of the United States Department of Agriculture and cabinet status for its head, the Commissioner of Agriculture. The national emphasis renewed the old conflicts and created some new ones as well. Some wanted national, USDA-run experiment stations; others wanted federal financing but state control, the question of who would exercise that control—the colleges, the legislature, the agricultural societies, or independent state agencies—becoming a subject of further controversy.

Given these disagreements, it is a wonder that any experiment stations ever appeared. But, as Marcus carefully shows, a few politically astute leaders managed to work out compromises that settled, or at least papered over, major differences, leading to the success of a few stations, mainly in the Northeast and the Midwest. Finally, compromise reached the national level, and in 1887 Congress passed the Hatch Act, which provided every state with a $15,000 annual appropriation to fund an agricultural experiment station. Although the new law did not completely satisfy everyone and did not end the old debates, it tipped the balance in favor of the laboratory scientists and the agricultural colleges.

Marcus has provided a valuable discussion of the early history of agricultural science and of the efforts of scientists to become professionals who would, through their scientific endeavors, provide leadership and direction to the nation's farmers. Although he recounts in great detail the oppostion the scientists faced in their task to legitimize their efforts, what is remarkable about the story he tells is how quickly the scientists won their point despite that opposition. Additional comparative studies of efforts by economists, business managers, and others who fought analogous battles would immeasurably increase our understanding of the role of science in the creation of modern America.

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An Educational Nexus

The School and the University. An International Perspective. BURTON R. CLARK, Ed. University of California Press, Berkeley, 1985. xii, 338 pp. $32.50. Based on a seminar, Los Angeles, July 1983.

The relationship between secondary and higher education, falling as it does between two specializations with different research agendas, has received relatively little scholarly attention. Yet this relationship governs the allocation of strategic educational opportunities and for that reason alone is a key factor in the way educational systems operate. This collection of papers addresses the subject at a timely moment as American secondary education is being berated in widely publicized reports for its academic failings. The collection provides, among other things, a chance to assess our educational system in comparison with those of other societies.

The contributions cover, in addition to the United States, Britain, France, West Germany, Sweden, and Japan—postindustrial countries facing similar problems in providing advanced education to a high proportion of young people—and Africa, China, and Latin America—developing societies where (especially in the first two cases) availability of educational institutions is a limiting factor. All the papers address a common set of issues, thereby facilitating comparison; rather than occasional pieces, the authors have provided factual accounts that elucidate basic characteristics of the

systems they deal with; and the comparative material manages to shed new light upon the implicit problematic—the state of secondary education in the United States.

Secondary education shapes the flow of students to higher education largely through curricular tracks and exit examinations. In most national systems a clear differentiation occurs at the upper, or postcompulsory, stage of secondary education, with the advanced academic tracks then being highly responsive to university influence. In addition, the instruments that actually govern transitions from secondary to higher education—secondary exit exams, university entrance exams, or, in the United States, standardized tests—have a powerful bearing on the nature and goals of secondary schooling.

Universities shape secondary education largely through the training of teachers and administrators. These effects are more difficult to document than those running in the opposite direction, but Clark suggests in his conclusion that the critical variable is the degree of university control over teacher training: the greater the university's influence, the higher the academic prestige of teachers and the greater the academic content of the curriculum they teach.

The two papers on the United States analyze these two channels of interaction by focusing respectively on students and on teachers. Carol Stocking's point of departure is the comparatively wide separation of secondary from higher education in this country. To bridge this gap a large and rather costly set of linkages has arisen, consisting of high school counselors, college recruiters, and the standardized testing industry. In the United States, unlike other countries, these mediations do little to encourage student achievement: since entrance to higher education is largely open, the structure of arrangements and rewards does not serve to motivate the majority of students. This feature of American education emerges with particular force from this comparative context.

Gary Sykes accurately depicts the structural characteristics that have prevented American teachers from attaining effective professionalization and higher status. One might quibble that the slant of his argument is largely foreordained by too liberal comparisons between independent professionals (chiefly medical doctors) and teachers, even though the latter are dependent employees offering what is almost a commodity type of service. But comparatively Sykes's point holds up. And thus his concluding exhortation that the status of the teaching profession be raised through more rigorous standards seems reasonable despite the formidable obstacles he has described.

In his conclusion Clark makes good use of the comparative perspective to depict the "distinctive problem" of American high schools in more general terms. Above all, the American weaknesses seem to stem from the desire to achieve universal secondary education in comprehensive schools. The difficulties are compounded by the close linkages with primary (rather than with higher) education, by local control (which inhibits teacher professionalism), and by geographical zoning (which tends to preclude choice among schools within districts). The result is a system that is singularly lacking in specialization, hierarchy, and competition. These seem to be precisely the qualities that energize upper-secondary education in other countries.

The moral that Clark draws runs counter to current reformist thinking within secondary education: "Americans need to consider whether noncompetitive and nonranked comprehensive high schools should be pushed toward competition, ranking and specialization" (p. 320). In other words, we might try to think in terms of carrots rather than sticks, of devising schemes that would draw greater effort from our students instead of forcing perfunctory fulfillment of numerous specific requirements.

The School and the University strikes a refreshing note in the recent debate over American secondary education, raising issues that require and deserve further exploration. It also constitutes a valuable guide for understanding the complicated pathways to and within higher education in the countries covered. Finally, it deserves recognition as an effective application of the comparative approach.

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Star Formation

Naissance et Enfance des Etoiles. Birth and Infancy of Stars. ROBERT LUCAS, ALAIN OMONT, and RAYMOND STORA, Eds. North-Holland, Amsterdam, 1985 (U.S. distributor, Elsevier, New York). xlii, 823 pp., illus. $159.25. Les Houches, Session 41. NATO Advanced Study Institute. From a summer school, Les Houches, France, Aug. 1983.

The universe we see when we look out to its furthest horizons contains a hundred billion galaxies. Each of these galaxies contains another hundred billion stars. That's 10^{22} stars all told. The silent embarrassment of modern astrophysics is that we do not know how even a single one of these stars managed to form. There's no lack of ideas, of course; we just can't substantiate them.

The observational evidence at hand is this: The most luminous stars observed in our galaxy, the Milky Way, are tens of times as massive as the sun, and hundreds of thousands of times as luminous. Given that these stars shine by converting hydrogen into helium, we know that only 0.7 percent of the central mass of the stars can be converted into radiant energy. Knowing how fast this energy is being radiated away, we can also calculate how long these stars can have been shining. That turns out to be roughly ten million years: These stars are young. They must have formed recently. Our sun, in comparison, is almost a thousand times older, and the age of the Milky Way may be 15 billion years.

The luminous young stars generally are found in the vicinity of dark interstellar clouds consisting of cold gas interspersed with dust grains that absorb starlight. The very youth of these stars, as well as their positional correlation with the dust clouds, strongly suggest that they form when cold interstellar dust clouds contract and condense into dense, massive objects—stars.

When we examine this hypothesis, which lies at the foundation of all modern theories of star formation, we immediately encounter three difficulties: (i) The contracting gas clouds must radiate energy in order to continue their contraction; the potential energy that is liberated in this pre-stellar phase must be observable somehow, but we have yet to detect and identify it. (ii) The angular momentum that resides in typical interstellar clouds is many orders of magnitude higher than the angular momentum we compute for the relatively slowly spinning young stars; where and how has the protostar shed that angular momentum during contraction? (iii) Interstellar clouds are permeated by magnetic fields that we believe to be effectively frozen to the contracting gas; as the gas cloud collapses to form a star, the magnetic field lines should be compressed ever closer together, giving rise to enormous magnetic fields, long before the collapse is completed. These fields would resist further collapse, preventing the formation of the expected star; yet we observe no evidence of strong fields, and the stars do form, apparently unaware of our theoretical difficulties.

The 15 short courses that make up the proceedings of this summer school together form an excellent introduction to the subject, as well as an outstanding summary of current thinking about star formation. The expositions generally are clear, largely self-contained, and documented with extensive lists of references to the literature. Many of the observational data at hand are summa-