one or more sciences in a medical school; some did not. Some were practicing physicians, others not. Many engaged in scientific research having little or no connection with medicine. Undoubtedly they were the backbone of the scientific community, but were they "professional scientists," either in fact or in their own estimation? If so, so were their 18th-century predecessors.

Unlike Daniels, Reingold ignores the medical community and concentrates on scientists connected with government operations of one kind or another, perhaps because his own researches have dealt chiefly with Bache, Henry, and others of their stamp. Undoubtedly the sense of professional identity was strongest in this group. But it is worth noting that Henry's contributions to physics, which were not inconsiderable, were made while he was a college professor rather than while he was a government administrator.

Daniels's sociological approach to the scientists of the Jacksonian period leads him to attribute to them a more self-conscious attitude toward themselves and other groups in American society than most of them actually had. Their frequent appeals to natural theology were not, as Daniels seems to suggest, a conscious "misuse of science" for the purpose of validating their professional status. On the contrary, the majority were evangelical orthodox Protestants who conceived science as the study of God's works. To represent them as "emerging professionals" concerting a careful strategy and tactics vis-à-vis a better-established group of professionals, the clergy, is to refashion history to make it conform to the dictates of modern sociological analysis.

Both authors make a strong plea for the importance of the kind of history of science exemplified in their books. Unfortunately, Daniels attempts to justify his approach by questioning the validity of another kind of history of science, the kind that focuses on the internal development of particular sciences and groups of sciences. It may be true that some practitioners of the "internalist" school have tended to judge past science in the light of current science instead of viewing it in its own context, but this "presentist" tendency afflicts all kinds of historians. Daniels himself is not completely free of it, as the comments above have indicated. Nor does Daniels strengthen his case by adopting Thomas Kuhn's distinction between "normal science" and "revolutionary science" and representing his own book as a study of "normal science" in the Jacksonian period. Whatever one may think of Kuhn's dichotomy (this reviewer finds it extremely dubious), it provides no basis for dismissing or undervaluing the internal dialectic of scientific thought. Kuhn himself is a strong adherent of the "internalist" approach to the history of science. And even Daniels must admit that a history of American science which makes very little reference to the scientific achievements of Joseph Henry, Asa Gray, and James Hall (to mention only three able scientists) is a little like *Hamlet* without Hamlet. Daniels and Reingold have made important contributions toward elucidating the structure and role of science in 19th-century American society. To complete the picture others must undertake to portray the work of American scientists of that period as an integral part of the intellectual adventure of Western man.

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In the Laboratory World: Reflections on Productivity

The Search for Understanding. Selected writings of scientists of the Carnegie Institution. CARYL P. HASKINS, Ed. Carnegie Institution, Washington, D.C., 1967 (distributed by Walker, New York). xxiv + 330 pp., illus. $6.

To celebrate the 65th anniversary of the Carnegie Institution, its biologist-president has brought together 22 essays, written by past and present members of the research staff, in what amounts to an institutional festschrift. Plainly, a research organization that, as early as 1904, could span the continent by establishing a Station for Experimental Evolution (now, the Genetics Research Unit) at Cold Spring Harbor and an observatory on Mount Wilson has much to celebrate. As an operating rather than fund-granting organization, it was a distinct social innovation to begin with and, in the fields of science which are its concern, it has been innovating ever since.

The papers in this volume reflect its wide-ranging interests: astronomy (five papers), genetics (two), embryology (three), plant biology (two), geochemistry (one), archeology (one), and, as by-products of these interests, the history, philosophy, and organization of science (with six papers that can be included here). The earliest of them—the classic paper by George Harrison Shull on the method of raising hybrid corn—appeared in 1909; the most recent one, by Merle Tuve, reflecting on the implications of complementarity for physics *and* the humanities, appeared in 1966. The score of authors comprise a galaxy of contributors to one or another branch of science in the 20th century.

This barebone description of the book is true—and thoroughly misleading, for it could give the impression that we have here a chaos of disconnected essays on diverse parts of science. The book is anything but that. Practically all the papers—both those that discuss the character of the scientific enterprise and the many more that exemplify some aspects of it—form a coherence by conveying a sense of both the mood and the practice of science. Much of this, I think, results from the quality of mind exhibited in them that transcends profound differences in subject matter. Common understandings about the nature of scientific work are transmitted across The Wall which, since the cold war was declared between C. P. Snow and F. R. Leavis (or even the older one between T. H. Huxley and Matthew Arnold), we have been told divides scientists and humanists. But the authors of this book, evidently nonbelligerents all, manage to communicate with readers of every description simply by reflecting upon rather than merely reporting their specialized work.

I was quite taken by Haskins's description of these essays as contributions "to the fine literature of science," a phrase whose meaning he goes on to explain: "If the [scientific] work is of philosophical cast, and if the writer, in addition to being a first-rate scientist, is also a first-rate man of letters, then there may be a rare by-product which can constitute one of the most enduring heritages of all for our culture, the brilliant scientific essay."

The principal unifying theme of the book is captured in its title, taken from an essay by Haskins's predecessor, Van-

nevar Bush. Almost without exception, the papers testify that the aim of scientific work is understanding, rather than the amassing of information and formulas. This central theme finds expression in a variety of subsidiary ones.

To begin with, there is the theme of the occasional tension between erudition and actual investigation in science, a tension there for the noting since at least the 16th century. It turns up in the essay by George Sarton, at the time of writing the acknowledged dean of historians of science, on "Leonardo and the birth of modern science." Sarton observes that "it was his ignorance which saved Leonardo. I do not mean to say that he was entirely unlearned, but that he was sufficiently unlearned to be untrammelled." In short, Leonardo would not permit books to stand between nature and himself. Abelson takes up the same theme in dealing with science today. Each investigator must decide what to read, how much to read, and how thoroughly to read in order to learn from others without getting "lost in the literature." "Some men spend so much time reading the literature that they never get around to doing anything." Galileo (and Harvey and others of that time) saw the problem as one of escaping from mere scholastic commentary. Today, the problem results rather from the vast expansion of the scientific literature. But it is with us still.

Another theme is that of the prime importance in scientific work of what can be described as "specified ignorance." This refers to the reasonably specific formulation of what we do not know in a region of inquiry, of why we want to know it, and, in the favorable case, of how we might proceed to find out. In his paper "The umbilical cord," for example, Samuel R. M. Reynolds conveys the importance of specified ignorance as he recounts, step by step, how he moved in on the question of the source of energy needed to push the blood through the veins at such high velocity. After having intermittently advanced toward an answer, in collaboration with the hydraulic engineer G. F. Wislicenus and the obstetrician Seymour Romney, he arrived at a final obstacle, the unknown mechanism of the inversion of pressure in vein and artery. He puts forth tentatively "the only explanation that can be offered at present," ending by saying, in monosyllables that would have gladdened the heart and head of the 17th-century historian of the Royal Society, Bishop Sprat: "But we do not know that this is so. . . ." The specification of ignorance becomes a prelude to another step in investigation.

Other papers in this volume exemplify the transition from scientific investigation actuated by informed and disciplined curiosity to major technological outcomes. It becomes evident that, back in 1925, when Gregory Breit and Merle Tuve conducted their experiments on the echoes of radio waves from the ionosphere, they had no thought that these would later become the basis for radar. So, too, there have been few more practical outcomes of scientific work than that signaled in Shull's account of the principles involved in developing hybrid maize, which, as Haskins notes, was estimated to have brought a gain of about $40 billion to the United States alone by 1952.

Implicit in several of the papers is the theme of the well-recognized importance of the *strategic research site* in scientific inquiry, the selection of empirical materials through which a problem can be investigated to particularly good advantage. It was only after extensive examination of various plants and animals that Shull hit upon corn as the most useful research material for his genetic inquiries; so, too, Reynolds and his associates decided to study blood flow in the umbilical cord because it "is easily accessible and contains only three major blood vessels," and Evelyn Witkin found that *Escherichia coli* was "an ideal vehicle for the experimental study of 'microevolution.'" A still-unwritten analytical chapter in the history of science would consider how the several sciences go about this search.

Reflecting upon the history of research on photosynthesis, Stacy French considers another principle of scientific growth: the limitations that are imposed on the possible development of particular subjects by incomplete knowledge in environing fields of investigation. His observation reminds us how permeable are the conventional boundaries between "different" fields of inquiry.

These are some of the explicit and tacit themes that give coherence to this highly diversified volume of essays. Each reader will single out his own favorite paper. As a sociologist of science, I am almost bound to choose Abelson's brilliant piece "Conditions for discovery." It is one of the most perceptive analyses of the effective microenvironment of scientific work that I have encountered among the many reflections by physical scientists upon their own experience and that of their colleagues. Perhaps this is only to say that I take comfort in the fact that what sociologists have been learning from their own studies of the behavior and environments of scientists is congruent with Abelson's observations.

The merit of his paper is that, unlike many others on the same subject, it is not confined to the individual attributes of scientists. These are important, of course, but to limit our observations to these is to neglect the basic fact that scientific work is inescapably social. Abelson recognizes that the working scientist is engaged in an unending series of judgments. He must decide what to investigate and when; if fortunate, he will benefit from the "instinct" for the scientific jugular and work upon a basic problem; he must decide upon the approach to take to the problem and improvise as needed to cope with unexpected difficulties. All this has to do with the behavior of scientists thought of as individuals. But Abelson recognizes that all scientists, even the so-called lone wolves among them, work in an environment comprised of other scientists. And he proceeds to give us a condensed and instructive account of the structure and functions of the creative microenvironment in science. Scientists who band together effectively tend to be complementary: in talents, skills, temperament, and knowledge. Abelson even recognizes the ordinarily neglected role of the "compromiser or peacemaker" in the work group (the role which sociologists such as Freed Bales have investigated under the rubric of "expressive leadership"). The key social mechanisms in these groups involve mutuality: mutual psychological support, mutual criticism, mutual instruction. There is nothing of the sociological Pollyanna in this account. Abelson recognizes that "men who have the capacity to create must have their share of pride and egotism. In a closely knit, tight environment, tensions and rivalries are always latent." Finally, he takes note that creative work cannot continue at a sustained high pitch. There is an ebb and flow of ideas.

If this volume is a prototype of the institutional festschrift, then I say let's have more of them.

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