



THE EXCITEMENT AND FASCINATION OF SCIENCE: Reflections by Eminent Scientists

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INTRODUCTION: *Reflections on Scientific Biography*

Accounts of the lives of scientists have enjoyed only a limited vogue in recent decades, both within the profession and in popular culture. Thus “what one does,” adduced to justify one’s findings, comprises the primary scientific literature, while “who one is” is omitted as a potential contaminant of objective scientific judgment. In science the personal life has been considered far less relevant to the search for truth than in more self-expressive fields such as literature and the arts. Hence tradition in scientific writing has discouraged use of personal pronouns and other manifestations of self.

Although folk heroes like Marie Curie and Albert Einstein have, by their unique achievements, made exceptional claims on popular interest, the conjunction of high scientific achievement, expository skill, and the time necessary for reflection and composition remains rare. Full-length autobiographies of genius, such as François Jacob’s recent book *The Statue Within*, are few and far between (5).¹ Even rarer are chronicles of workaday scientists, who produce the substance of most scientific advances (4).

While the scientist’s restraint from self-description may have helped to preserve the purity of the logic of justification, the indispensable critical function in science, it has also deprived us of insight into the personal and social processes that motivate discovery and pervade the scientific effort. We are left with narratives of chase, competition, and interpersonal stress rather than accounts of imagination gratified and cooperation achieved. Today’s youngsters contemplating scientific careers indeed deserve more life-sized and sophisticated portraits of their role models than my generation had in de Kruijf’s *Microbe Hunters* (1926)—but also truer portraits than the melodrama that now makes the bestseller lists and electronic media. The prefatory chapters collected here provide an antidote to these extremes. Many are autobiographical, and these have an appeal far beyond the specialty interests of a given series, be it the *Annual Review of Genetics* or the *Annual Review of Astronomy and Astrophysics*.

This collection, Volume 3, which includes chapters that appeared originally from 1977 through 1987, embraces a broader range of subject matter than did Volumes 1 (1965) and 2 (1978).² But despite its breadth of coverage, Volume 3 includes only a large fraction of the prefatory chapters published during the period. Not included were some so technical (where, for example, “Σ”

1. Literary geniuses have often expressed themselves in autobiography, but we do not often find such practiced expository skill among scientists; and the problem of rapport with a broad readership on arcane subject matter is an additional grave hindrance. The knack of simplification is a gift. This truth and the fact that simplification must distort complex knowledge have deterred most scientists of genius from autobiography.

2. An index to all prefatory chapters published in all of the *Annual Reviews* through 1987, whether included in these collections or not, appears as an appendix to this volume.

appears more frequently than “I”) that our lay readers might have found them arcane. Others were excluded that address broad issues of great general interest but are not in the autobiographical mood of the present collection. Several *Annual Reviews* are not represented here at all, since some editorial committees do not invite chapters in this genre. Prefatory chapters in the *Annual Review of Psychology*, for example, are not autobiographical, the series coeditors having determined that the “History of Psychology as Represented in Autobiography” (14) is the more appropriate vehicle for such contributions. As another prefatory variant the *Annual Review of Phytopathology* has published numerous contributions on the history of the discipline.³

Arrayed in Volume 3, then, are more than five score chapters that hew close to the central line of autobiographical memoir. Their authors were selected by their peers on the editorial committees of the various *Annual Reviews* as certified successes in their fields who had worthy stories to tell. Indeed they comprise a sample of the highest achievers, and they write about the scientific issues of greatest interest to the readers of the *Annual Reviews*. (Few of these authors would have cared to write detailed “confessions” in the style of a Rousseau, Proust, Sartre, or Jacob.) Originally offered without a thought about eventual republication for a wider audience, these memoirs have much to communicate both to scientists and to the broader public.

These two thousand and more pages of autobiographical reflections could provide the raw material for a doctoral dissertation’s worth of analysis, whose annotations might in turn fill a volume (3). Since my present purpose is to assess what the genre has to offer, I will only suggest a few generalizations about scientific biography. To the questions “Why write it?” and “Why read it?” I respond that it can offer at least five sorts of perspective:

- on the substantive content of science;
- on the philosophy of science as a process of discovery and verification;
- on science as a social institution;
- on the relationship between science and the forces that shape human individuals; and
- on the history of science.

The Substance of Science

Biography engages public interest in a body of scientific work. Contemporary books like those of S. E. Luria (15), Maclyn McCarty (16), and Arthur Kornberg (11) may attract audiences far wider than the one with the background to assimilate the authors’ original research. But biography as a way of

3. Although not reprinted here, those chapters are all recorded in the appendix to the present volume, as are the chapters in *The History of Entomology*, a volume published in 1973 by Annual Reviews Inc. and now out of print.

teaching science is often frustrated by the scarcity of luminaries: There are few figures whose work, like Einstein's (19), can characterize an entire field. Collective biographies, like Kevles's on the physicists and the geneticists (9,10), Rhodes's on the atomic bomb (20) and Judson's on molecular biology (6), are one means of broadening the vista. The autobiographical memoir that focuses on a set of scientific issues as much as on the personality of the author may also help to fill the gaps among portraits of giants. Most of the accounts in this volume well serve the latter purpose. In fact many of the individual memoirs in the present volume do inadvertently reinforce their neighbors.

For scientific substance, our memoirs will be more helpful in enlarging than in initiating an understanding of a field.

The Philosophy of Science

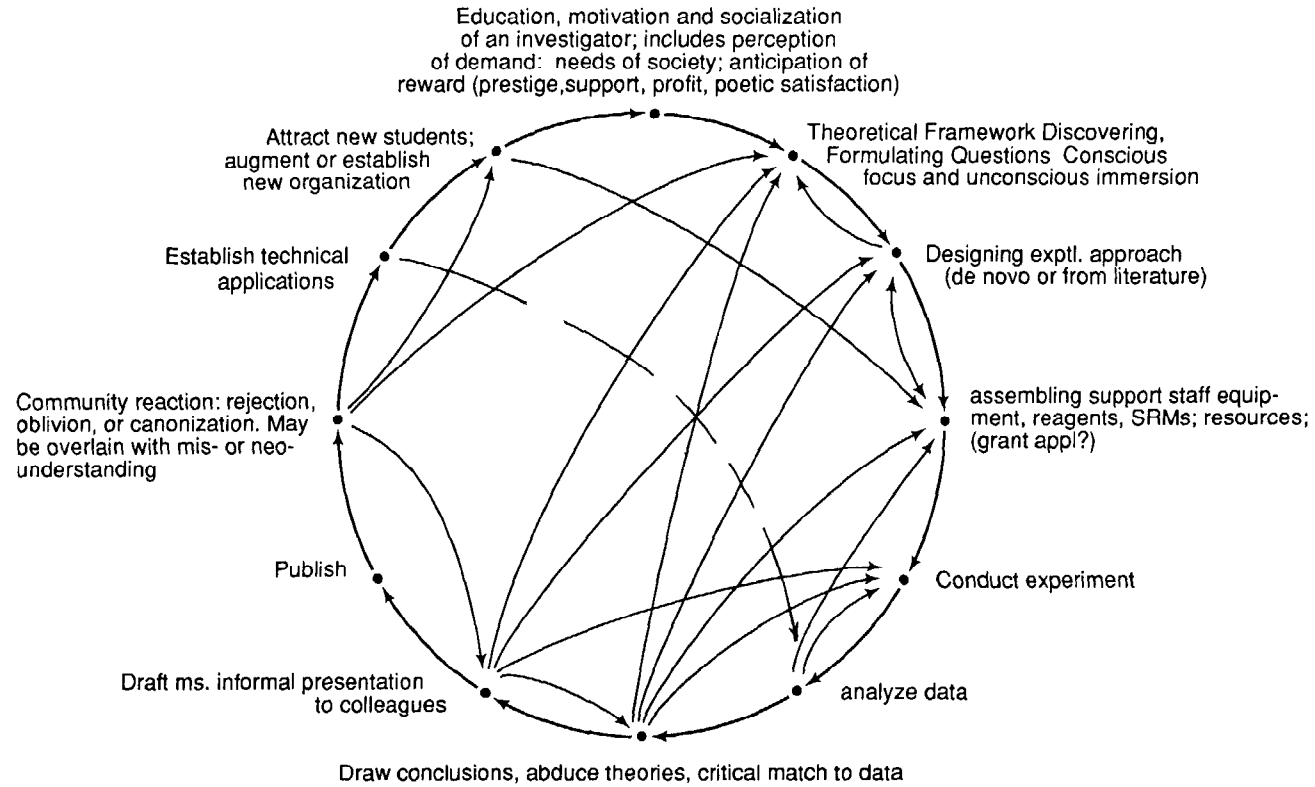
Very little of what is published on the philosophy of science is informed by firsthand encounter with laboratory investigation (and vice versa). A number of this volume's memoirs treat, more or less explicitly, the logic (and mathematics) of verification. The logic of discovery, if there is one, is the implicit agenda of most of them. Such an agenda can be difficult to trace, of course, when the objects of discovery are the province of a scientific specialty.

In Figure 1 (*overleaf*), I posit a rough guide to the steps, or rather interlocking cycles, of cognitive method in scientific discovery. The nodes are not always sequential; each must be drawn with return arrows — regressions to prior stages in response to new insights, data, opportunities, and constraints. The figure is drawn from introspection, not from analysis of the memoirs collected in this volume, which may or may not corroborate this conventional model. The claims of the grant-writer notwithstanding, scientific progress and its translation to the fruits of technology are far from simple linear processes. In research practice, the reverse loopings far outnumber the incremental steps. Contact with other scientists and their ideas, by personal encounter, the literature, bibliographic retrieval systems, *Annual Reviews*, is more pervasive than is exhibited in this diagram or written in the memoirs. Rarely do scientists recall how they made such contacts (2).

The Sociology of Science

Missing from most primary literature in science are all but the faintest clues about the social context of discovery—how the scientific community is shaped by its operating norms and institutions, as well as by its fraternal and intergenerational networks (8). The proliferation of multiple authorship does suggest imperatives of collaboration, especially as the technology of experimentation becomes more specialized; and appended acknowledgments of the funding of ever more costly instruments give some hint of the

Epicycles of Scientific Discovery



dependence of science on the larger community. Likewise, the application of science to the search for solutions to many of humankind's gravest problems manifests the institution's social aspect.

Biography depicts directly the personal relationships among scientists, their mutual debts, their etiquettes, sometimes their jealousies and transgressions. Rarely among our pages, however, do we find signs of a competition as intense as that attributed by Watson to the race for "The Double Helix." Perhaps the stakes of that race are matched only a few times in a century, so that such a chase engenders a ferocity foreign to even the highest accomplishments of less notoriety. For the most part our authors have not attained, nor did they seek, the degree of public attention that warrants full-length biography. Their personalities, though less flamboyant than those celebrated in the daily headlines, are far more typical of practicing scientists.

Enmeshed in society, scientists may also find themselves with extra-scientific responsibilities and roles, though each of these is grounded in the fundamental one of discovering and telling the truth (13).

Our chapters abound in examples of the researcher doubling as teacher and publicist; organizer and manager; inventor, agent of technology transfer, and developer of useful applications; adviser to government or industry; prophet; and paragon. Caveat: perhaps those who write are a socially and self-selected sample; others may insist on staying at the bench to the exclusion of all else.

An elucidation of the social conditions of science is the province of an authentic discipline of social science (1,17). Such an understanding is indispensable in the management of the institutions of science, in the optimal search for and nurture of creative talent, and in the most socially beneficial allocation of scarce resources. If the confidence and support of the larger society are to be sustained, the public must understand how in the practice of science a system of reward for personal ambition is melded with, and only rarely contravenes, the search for truth.

The Psychology of the Scientist

Among the first questions addressed by biography is often the choice of career: "Why do science?" With varying explicitness, our authors provide answers that involve

- curiosity—the exercise of intellect and of aesthetic taste
- virtuosity—the prestige and self-satisfaction they derive from the practice of extraordinary skill
- power—influence and vanity — the fruits of "success"
- illumination—compulsion approaching the religious, associated with peak discovery

- service—in reaching other minds and in generating useful knowledge

The scientific life is hardly devoid of drama, but one may have to plumb a depth of circumstantial detail — nuances of personality and of science — to become aware of it. Equipped with introspection, however, the reader may readily recognize in these chapters a substantial number of stresses and contradictions in the scientific life (3,12,18), conflicts between sets of norms:

- imagination vs critical rigor
- iconoclasm vs respect for established truth
- arrogant audacity toward nature vs humility and generosity toward colleagues
- efficient specialization vs broad interest
- experimentation vs reflection, reading, speculation
- ambition vs sharing of ideas and tools
- celerity (priority) vs deliberateness (reliability)

Broadly speaking, these match the Dionysian and Apollonian ideals.

Why does the scientist write a self-advertisement, an *apologia pro vita sua*? Perhaps most of all to gain self-understanding. The most useful public function may be to inspire a new generation to enter a scientific career, and to exemplify the highest ideals of the profession.

History

No contemporary scientist has worked and thought in a vacuum; the presentation and solution of problems are part of a history of ideas. The greatest discontinuities pose the greatest challenge to understanding. Why are some ideas so “premature” as to meet fatal resistance when first published? One thinks of Gregor Mendel, whose far-reaching experiments were ignored during his lifetime, as an uncontroversial example.

Because the scientific method in practical use is so complex, the course of science is subject to numerous noncognitive, social influences. We know little, for example, about what informs the creative imagination (7). In a review of a prior discovery account of my own, Harriet Zuckerman and I suggested that discovery might sometimes be “postmature” (22). (That such terms as “pre-” and “postmature” imply a preordained rhythm of discovery we are well aware.) We see a “postmature” discovery as one deterred by a hindrance at one step in the cycle (see Figure 1) prior to publication, most of the other ingredients being in place. A discovery resisted in this way then deprives the intellectual milieu of precursors for putative subsequent

discoveries. We acknowledge that the hindrance may lie in the creative faculty itself; but retrospection often reveals so many close calls that we wonder whether some particular impediment could have been relieved at an earlier stage. Clearly the social system of science, with its roots in the selection and nurturing of talent, does not function perfectly, without friction or dissipation. This is no surprise, since its processes remain barely examined (17).

Informative for the historian of science these pages likewise comprise social and political history (21). This and prior volumes of *The Excitement and Fascination of Science* are replete with world events. The migrations from the Europe of the Tsars and later of Hitler, the mobilizations of World War II, and the postwar Red scare blacklists are recurrent themes. The extra-scientific preoccupations of many of our writers are touched even more deeply by that historical context than are the details of their scientific output.

The various brief contributions in Volume 3 rarely answer all the questions implied in this introduction. However, authors of future memoirs (and, happily, of most of the present ones) are currently thriving. We may hope for further work touching on these themes.

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