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A Tribute to Derek John de Solla Price: A Bold, Iconoclastic Historian of Science

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On September 3, 1983, Derek John de Solla Price died suddenly in London. He had been visiting with our mutual friend and colleague, Anthony Michaelis, editor of *Interdisciplinary Science Reviews*. When I heard of Derek's death, I wondered why he had taken the risk of flying to London so soon after recovering from major surgery for an aneurysm. But at a memorial ceremony at Yale University, his son Mark suggested that it could not have been otherwise. It would have been out of character for Derek to refrain from pursuing his work and interests. He is survived by his wife, Ellen; sons, Mark and Jeffrey; daughter, Linda DeMichelle; sister, Joan Cravitz; and three grandchildren.

For me, perhaps one of the most regrettable aspects of Derek's untimely death is the lost opportunity to have coauthored a book or paper with him. But it would do no good to be lugubrious about this matter. Death becomes more prevalent as one grows older and accumulates colleagues the world over. That is a price scholars must pay for the privilege of acceptance into an invisible college. But, somehow, we survive these traumas. However, the loss of a friend such as Derek Price, who was more like a brother to me than a colleague, demands some special attention. Although offering him this posthumous recognition is important to me, it is gratifying to know that Derek was alive to read the special tributes to him which I published in *Current Contents*® (*CC*®) on at least two occasions.[1,2] I am equally glad that I pressed him to do a commentary[3] on his classic, *Little Science, Big Science*.[4]

Numerous tributes to Derek Price have already been published by colleagues who knew him or his work. Belver Griffith, Drexel University School of Library and Information Science, has praised Derek's contributions to our understanding of the role of science in society.[5] Manfred Kochen, University of Michigan, Ann Arbor, provides a brief review of Derek's career, and credits his influence upon the entire first generation of information scientists.[6] Douglas H. Shaffer, editor, *National Association of Watch and Clock Collectors Bulletin*, praised Price's contributions to the field of horology,[7] the science of measuring time. Susan Crawford, Medical Library Association, wrote of Price's work on the problems of information handling.[8] And in a moving tribute, Alan Mackay, Department of Crystallography, Birkbeck College, University of London, described the multifaceted nature of Price's talent. In an oblique reference to the streak of iconoclasm which Derek possessed, Mackay wrote: "[We] will remember Derek in his accustomed role of expositor of the prospects for the future, the stupidities of the present and of the treasures of the past."[9]

I was asked to write a brief eulogy to Derek for the first issue of *Information Today* in November 1983.[10] Along with

many of his friends, I was also asked to contribute an article to a *festschrift* issue of *Scientometrics*, to be published next year. That article discusses the multidisciplinary influence of *Little Science, Big Science*.[11] In these and other publications, I have often spoken of Derek's pioneering role. He uniquely brought together the history of science, scientometrics, and information science, and made an enormous impact on scientific communication. In none of these instances, however, was I able to fully cover the many facets of his creativity. That would take a long-term, collaborative effort by a multidisciplinary research team which would include some of his close colleagues. So what follows will discuss an often-overlooked aspect of Derek's scholarship: his passion for scientific apparatus and his work showing the importance of technology and methodology in the advancement of science.

Derek Price was best known, of course, for his work in scientometrics and the history of science, for which he received a second doctorate in 1954 from the University of Cambridge. But his scientific contributions have not been limited to those fields. His early papers, for instance, were in mathematics and theoretical and experimental physics. Indeed, he had earned his first doctorate in experimental physics in 1947 from the University of London. His lifelong interest, however, was in scientific instruments and hardware.

Born in Leyton, a northeast London suburb, Price was educated in British state schools. His early inclination toward science was derived, at least in part, from a steady diet of science fiction "pulp" magazines. He expanded his scientific horizons during World War II, assisting in military research on optical characteristics of hot and molten metals.[12] He also taught college-level science courses for armed services training programs. In 1947, degree in hand, he accepted a three-year position teaching applied mathematics at Raffles College (now the University of Singapore) in Malaya.

His stay at Raffles was a pivotal point in his career. First, it was during this time that Price made his now-famous discoveries about the exponential growth of science. The college had acquired a complete set of the *Philosophical Transactions of the Royal Society of London*, which had its inception in 1665. Price stored the bound volumes in his home while the college library was under construction. Taking the opportunity to read them cover-to-cover—and thereby gaining his initial education in the history of science—he noticed that the chronologically stacked volumes formed an exponential curve against the wall. Surveying all the other sets of journals he could find, Price found that exponential growth was an apparently universal phenomenon in the scientific literature. He gave a paper presenting his observations to the Sixth International Congress for the History of Science in Amsterdam in 1950.[13] This paper marked his transition from physics and mathematics to the history of science. Although the paper was initially ill-received (in Derek's words, "It went over like a lead balloon"), Price nevertheless entered Cambridge to pursue a doctorate in his newly chosen field.

Price's stay in Singapore also led him to develop an interest in Oriental culture. When he was made honorary curator of Cambridge's Whipple Museum of Antique Scientific Instruments, this interest led him to collaborate with Joseph Needham and Wang Ling on a book and a paper covering the history of medieval Chinese clockwork.[14,15] Published in *Nature* in 1956, the paper stated, "The invention of the mechanical clock was one of the most important points in the history of science and technology," allowing for the first time the accurate measurement of processes over time.[14] The then accepted view was that me-

chanical timekeepers, powered by a falling weight, were an innovation developed in Europe in the early fourteenth century. However, Price and colleagues, among others, demonstrated that the Chinese tradition of water-powered astronomical clockwork directly contributed to the development of late medieval European mechanical clocks.

Price made an important discovery by accident some years earlier while writing his thesis on the history of scientific instruments. Carefully sifting through medieval literature, he stumbled upon a Middle English manuscript by English poet Geoffrey Chaucer. It described the construction of an instrument for calculating planetary motions. Price identified the beautifully handwritten paper as a companion piece to Chaucer's 1391 *Treatise on the Astrolabe*. He then proved it to be the poet's draft manuscript, the only extensive piece in Chaucer's own hand known to exist.[16,17]

One of Derek's proudest achievements, however, was the solution to the problem of the Greek Antikythera mechanism. An artifact of the first century BC, it was salvaged by the first underwater archaeological expedition in history in 1900. The mechanism featured prominently in all accounts of the history of scientific instruments as the earliest known example of a "technological" tool, but its function was unknown, since it was encrusted within a mass of coral, shells, and other debris. Using the technique of gamma-radiology, however, Price was able to photograph the interior of the corroded mass. A painstaking analysis showed the existence of differential gears. This proved that the Antikythera mechanism was a mechanical calendar exhibiting a level of sophistication and refinement not previously thought possible in such an early culture.[18-20]

Derek's last paper, "Of sealing wax and string,"[21] combined his love of scientific apparatus with his expertise in the history of science. Its posthumous publication in *Natural History* led me to reflect on what may have been one of his most important messages, suggesting that instrumentation has been of far greater importance in the history of scientific achievement than has been suspected. An extensive quote from the article follows:

> During the golden age of experimental physics early in this century, all progress seemed to depend on a band of ingenious craftsmen with brains in their fingertips, who exploited a great many little-known properties of materials and other tricks of the trade. These tricks not only made all the difference in what could or could not be done in the laboratory; to a large extent, they determined what was discovered....
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> The flavor and tradition of this experimentation are markedly different from, and perhaps even in conflict with, the standard view of the role of experiment in science....
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> The standard view...is that the scientist creates hypotheses and sends them out to be tested by making a trial of the prescribed 'experiment.' Herbert Butterfield and Thomas Kuhn have described the inspired thought that leads to great and revolutionary changes in science as 'shifts in paradigm.' According to this view, the thought is what's important; laboratory instruments...exist only to confirm or invalidate what the thinker has hypothesized.
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> What actually goes on in laboratories is of a different nature. Since the seventeenth century...experiment has more often meant 'experience' in the use of various techniques. The idea is to find out what will happen when you try certain techniques, and the hope is that in finding out, you will discover facts of nature that fall outside the range of what was known before. The procedure is far from being cut-and-dried, and the theoreticians and experimenters far from being in the master/servant relationship in which they are usually cast.... Skilled experimenters are masters of a...crucially important technology. Their work is

> at the core of high technology and represents a tradition that is autonomous and did not arise from the cognitive core of science, but from other technologies devised for quite different purposes. Much more often than is commonly believed, the experimenter's craft is the force that moves science forward.

By now, a considerable literature on the importance of methodology and technology in the advancement of the scientific enterprise has accumulated. In our discussions of highly cited papers, we have emphasized that citation analysis highlights the importance of new or improved methods or instruments. Every list of highly cited papers includes a sizable group dealing with new or improved techniques for analysis. Hundreds of the *Citation Classics* ™ we have published illustrate this point. Unfortunately, we do not yet have any systematic data or analyses that would permit one to draw major science policy conclusions. Have we, in fact, given appropriate priority to those seeking support to produce new methods? Or must these techniques be smuggled in under the cloak of basic research?

Without making invidious comparisons between the intellectual value of theoretical or conceptual research and that of instrumentation or methodology, there is a bias in the way the public and the press perceive these two interacting phenomena. And in fact, scientists themselves often use denigrating terminology when speaking of "mere" methodology, or "mere" technique, or "mere" equipment. However, Derek Price produced incontrovertible evidence that technology and methodology open up entirely new areas of science.

The mind and talent of Derek Price were unique. Consider the size of the worldwide scientific enterprise: at least a million scientists are involved in research. Even when we limit discussion to the 100,000 or fewer who contribute the bulk of new knowledge, it is remarkable how unusual each of them is. When the number is reduced by another order of magnitude, and the discussion confined to the 10,000 or so most influential scientists—including some like Derek Price—we realize even more fully how unusual such persons are.

There will never be another Derek Price. It is good to know that others will go on to help illuminate the paradigms he established. But no one is in a position to continue the projects that were uniquely his, to carry on where he left off. Derek himself acknowledged that he, like hundreds of other scholars, had not sufficiently sought or trained candidates for his own replacement. If the National Science Foundation or some other body were to manage science as one tries to manage a large institution or corporation, this important matter of intellectual succession would be given more serious attention.

I have no doubt that the crowning moment of Derek's career was his election, just before his death, to the Royal Swedish Academy of Science. He wrote to me about this with obvious glee and pride. He planned to begin a systematic procedure for nominating candidates for the Nobel prize. His membership entitled him to this privilege. This was not a trivial challenge, but I am sure he would have met it admirably. And we both knew the pitfalls of citation analysis well enough to use the data wisely.

Derek Price was one of the most ardent supporters of the use of unobtrusive methods for identifying significant science. He was often overly zealous in what he had to say on these matters, as any of us who knew him personally had many an occasion to discover. But as with so many of his pronouncements, he always seemed to succeed in drawing attention to ideas and problems that may otherwise have lain fallow. And although his provocative style and bravado caused many a raised eyebrow, whenever he was caught in an outrageous

simile or metaphor, he happily corrected himself. When the definitive biography of Derek Price is written, it will surely note his flair for the dramatic.

Derek wrote so much that was original and that truly mattered that it would be a life's work to separate what had ultimately proven right from the rest. The main point is that he got everyone's intellectual juices flowing. And, to say the least, that was always exhilarating. The loss of this exciting and dynamic man, of his ideas and his contributions, is one that will be felt not just by his friends, but by the whole scientific community.

Mackay, in particular, stressed Derek's role as a member of the Advisory Board of the *Science Citation Index®*, and his close association with me and, later, Henry Small and others at ISI®. We both served as founding editors of *Scientometrics*, together with V. V. Nalimov and others. That journal has now established the Derek Price Medal to help perpetuate the memory of this gifted person. While preparing this tribute to Derek, I was informed that I would be the first recipient of the medal bearing his name. This medal will always be symbolic to me of the special relationship Derek and I shared.

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