percent of the students in the test section were very close to those of the honors section and substantially better than those of the control sections. In fact, the scores of most of the test-section students compare favorably with the control sections except in the very lowest scoring intervals, in which the test-section students were distinctly poorer. (There is some evidence that the poorest students in the test section had not taken the programs very seriously and had generally procrastinated in their course work.)

The experimental results must be regarded as less than conclusive because of the small student numbers involved. Furthermore, the Hawthorne effect may have been operative, that is, the students in the experimental group may have been motivated to try harder merely because they were receiving special treatment. For use in program improvement, more data will be sought in further tests on the extent and details of student use of the programs.

The experiments described demonstrate some success for teaching tactics which combine instructors in the classroom with home study from programed texts. Although the preparation of the programed material was formidably expensive, this expense was largely capital investment, that is, it is amortized with widespread or repeated use. The cost of program preparation per student hour is substantially lower than that of movies. We suspect that one reason more funds are being expended upon preparation of instructional films rather than instructional programs is that the films fit in more readily with established instructional arrangements and thus gain ready acceptance. However, the potential for gainful reconfiguration of instructional schemes when programed materials are used suggests that such materials may have the greater promise for over-all learning improvement.

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Peter Debye—An Appreciation

F. A. Long

Peter Debye came to Cornell University in the winter of 1939–40 to give the Baker lectures in chemistry. He was then 55 years old, a Nobel laureate who was universally considered one of the scientific greats of the 20th century. I was a freshly appointed assistant professor at the time and had no knowledge of the complex circumstances that brought Debye to the United States, but I do recall the sense of satisfaction that pervaded the chemistry faculty when the word was passed around that Debye was in fact coming. I also recall the enthusiasm which greeted his lectures. Those lectures were lively, vigorous, and filled with that sense of intellectual excitement which I came to realize was a Debye hallmark. The young faculty members at Cornell were all delighted when we were told that the department was trying to persuade Debye to stay on as professor and chairman of the chemistry department; we were overjoyed when he accepted.

Debye was to stay at Cornell, first as professor and then as a very active emeritus professor, for 26 years—much the longest time he had ever spent at any one university. His influence on the Cornell chemistry department and indeed on chemistry in the United States was profound. But in recalling some of the things that made Debye the very great man he was, I find myself thinking of Debye in very personal terms, what he was like as a person and of how others reacted to him.

The most characteristic aspect of Debye was his unflagging enthusiasm for science. Nothing pleased Debye more than hearing and talking about what he called a "good idea." He was a very friendly man and always welcomed visitors, but he particularly welcomed visiting scientists who wished to talk science. He was also a very courteous man and was quite prepared to talk on the visitors' terms. But, given a proper opening, he would delightedly talk on his own research or, more specifically, on his latest "idea." It was then that his face would light up, his smile would broaden, and the equations would stream from his chalk or pen.

Debye was remarkably sensitive to the level of understanding of his audience. He could successfully explain scientific ideas to school children, to colleagues, to graduate students, and to business executives. And as he explained, he invariably also communicated his personal enthusiasm for science.

Although one automatically thinks of Debye as a theorist (the Debye theory of dielectrics; the Debye-Huckel theory; the Debye law of specific heat; and so on), his approach to problems was not fundamentally a mathematical one. He was a model-builder. In discussing a new theory his first question usually was, "What is your picture?" One of my warmest memories of his particular approach concerns a colloquium lecture when he was giving the development of the now famous equation for light-scattering by solutions. Having presented most of the development, he then said, "Now you see we have almost everything, but our equation is dimensionally incorrect.

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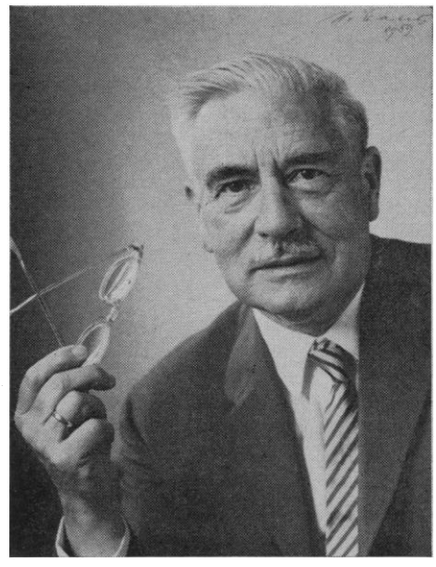
What must we do to make it correct? We must put, in the denominator, λ^4." I still recall the delighted smile and flourish with which he completed his equation.

Debye was a famously successful industrial consultant, and his ability to communicate both ideas and enthusiasm was one of the reasons for his success. But there were other reasons. One was Debye's great knowledge of the physical sciences and their interrelations, a knowledge which made it possible for him to explain data and suggest critical experiments in a great variety of research areas. Another reason, of particular interest to industrial research directors, was his concept of the role of basic research in industry. Debye believed that, for the solution of most applied problems, an engineering approach based on existing knowledge was likely to be the most expeditious. In his view industry's reason to carry out basic research, parallel to engineering development, is to provide relatively inexpensive backup to the engineering approach in the event that this runs into trouble. Since basic research is also the idea generator for the next generation of applications, Debye argued that there is a double case to be made for industry itself to carry out a program of basic scientific research.

Debye's personal involvement in research continued to the day of his death. As an emeritus professor with sponsorship from the Office of Naval Research, Army Research Office Durham, Air Force Office of Scientific Research, and other federal and industrial agencies he maintained a substantial group of postdoctoral research associates. He was a very permissive supervisor and strongly encouraged his students to develop their own ideas and methods even when he disagreed with them. Indeed I recall his once saying about a theory developed by one of his good students, Fritz Bueche, "I don't like the way Fritz makes that calculation, but Fritz likes it—so he should do it his way."



Peter Debye [Photo by W. Mantz]

Debye was always easily persuaded to give a lecture or to attend a scientific conference. In fact his first mild heart attack occurred in Kennedy Airport when, aged 81, he was en route to Rome to be chairman of a symposium which he had arranged for the Papal Academy. Only the combined efforts of his son and his doctor prevented him from resuming his travels when he learned that the attack was merely a "cardiac insufficiency"!

When Debye went to a conference he participated fully. At a recent conference, after he had just given his own talk in a morning session and was returning to listen to the afternoon session, one of his friends suggested that, given his 80 years and the 9000-feet altitude, he might preferably rest. Debye's reply was characteristic: "No, no, no; if I listen to the talks I may get some new ideas."

Debye was an affectionate husband, father, and grandfather. His principal hobbies were gardening and fishing, and both were done with the steady participation of his wife. In 1948, when the Debyes were well over 60, they took over the principal upbringing of two of their young grandsons, and it was a matter of great pleasure to Debye that, by the time of his death, both of the boys were successful graduate students, one at Georgetown University and the other at Cornell.

In 1960 Debye was awarded the Nichols Medal. This award was, incidentally, one of many such; Debye may have been the most honored and decorated scientist of all time, and he was always pleased by each new medal. At the Nichols-award dinner I had the happy task of making a few remarks about his career, and among other things I commented that had he not been given a Nobel prize for his pre-1940 work, his post-1940 science would have made him a deserving candidate. In retrospect I am only sorry that I didn't make this point with much more vigor.

This then was Debye; an incredibly able and active scholar for over 60 years, one of the last of the great classicists of physics, a stimulating teacher, a courteous and obliging colleague, and first, last, and always an enthusiastic dedicated scientist. Since one of Debye's most endearing characteristics was his love for what he called his "little jokes," it seems appropriate to finish these comments with a story, not told as a joke at the time but clearly one in retrospect. Shortly after World War II, the distinguished James Franck, formerly of Göttingen and then at the University of Chicago, visited Cornell, and, at an evening party, not attended by Debye, the topic turned to the physicists. Franck then said something along these lines, "Of all of us Debye is potentially the greatest. He is one of the smartest physicists I have ever known. What a pity he doesn't apply himself harder!"