Part One
Background, Theory, and Concepts

FRET – Förster Resonance Energy Transfer: From Theory to Applications, First Edition.
Edited by Igor Medintz and Niko Hildebrandt.

1

How I Remember Theodor Förster*)

Herbert Dreeskamp

I first met Theodor Förster in 1959, after my postdoctoral years in the United States, at a conference on fast reactions organized by Manfred Eigen in the Harz Mountains. Very prominent scientists attended, such as Eyring, Noyes, and the three men seen in Figure 1.1 (from left to right) George Porter, Theodor Förster, and Albert Weller.

Half a century ago "fast reaction" meant flash photolysis in the microsecond range by Norrish and Porter or relaxation methods by Eigen. As I remember, it was Förster who pointed out clearly that the term "fast" characterized our technical facilities at that time rather than the scientific problem at hand. The time range of fast chemical reactions may better be characterized by the rearrangement of electrons in the 10^{-16} s range, the vibration of nuclei in the 10^{-12} s range, or the deactivation of electronically excited states in the 10^{-9} s range. Thus, if there are reactions of electronically excited states – and after all, molecules do have characteristically different properties in their different electronic states – you will be able to investigate these reactions in the nanosecond range by just studying fluorescence, which is emitted in competition to these photochemical reactions. And since Förster had, at the beginning of his career, studied the absorption spectra of organic compounds, that is, the electronic structure of their ground and excited states, he was able to find the proteolytic reactions of aromatic compounds as the classical example of using fluorescence to investigate fast chemical reactions. To me this example shows clearly, in a nutshell, Förster's approach to the scientific problem and why he was so extremely successful in opening new avenues in photochemistry.

Sometimes it was said that he was gifted by a remarkable intuition. I am sure his intuition was the result of strict devotion to science, very hard work, his enormous

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*) This chapter is based on a talk given by the author at the International Bunsen Discussion Meeting on "Light Harvesting and Solar Energy Conversion," March 29, 2010, Stuttgart-Hohenheim, commemorating the 100th birthday of Theodor Förster (1910–1974). The author studied physics in Bonn and Paris, spent decisive years 1960–1970 with Förster in Stuttgart, and was professor of physical chemistry at the Technische Universität Braunschweig. He thanks Dr. Eberhard Förster, son of Theodor Förster, for the pictures used in this chapter.

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Figure 1.1

knowledge of the literature, and his insistence to reach a complete understanding of the problem at hand.

Theodor Förster was a son of Frankfurt am Main, like Otto Hahn (as shown in Figure 1.2, second from left, and Förster is the first from right). He got a training there as a theoretical physicist when both he and quantum mechanics were quite young (Figure 1.3). As an assistant to Karl Friedrich Bonhoeffer in Leipzig, he came under the influence of such eminent men – besides Bonhoeffer of course – as Heisenberg, Kautsky, and, I think particularly, Peter Debye. Since those Leipzig days there is the most remarkable and efficient interplay between theory and experiment in the work of Theodor Förster.

Figure 1.2

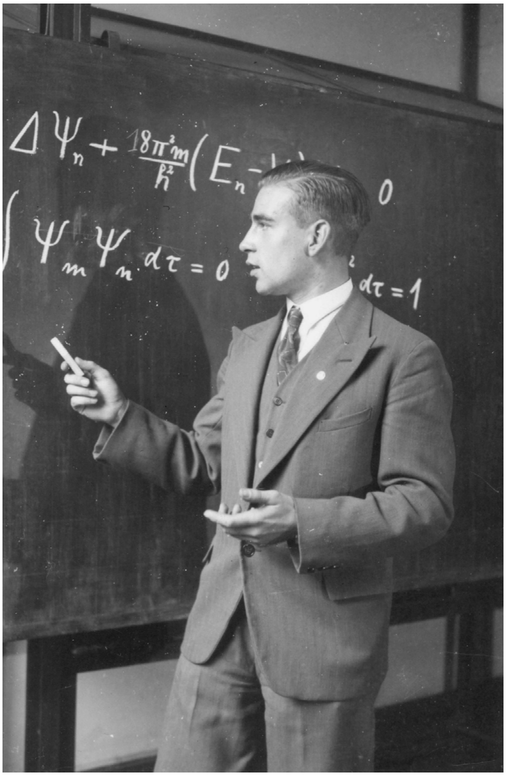

Figure 1.3

His aim was to search for the most appropriate solution of the scientific problem, or in his favorite words: “Die richtige Deutung einer Beobachtung” (*The correct interpretation of an observation*). This included taking carefully all information into account, separating the important from the trivial, designing a simple experiment, and arriving at the correct interpretation, if possible, without any too elaborate computer analysis. For me, this picture (Figure 1.4) from the Posen or Göttingen years – the 1940s – may illustrate what I tried to say: Brains seem to be more important than fancy equipment or powerful computers.

Very often it was both a relief and a delight for all of us who were present, when after a somewhat incomprehensible seminar talk he would stand up and quite politely say, “If I understand you correctly, you meant to say this and that . . . ” and he would give in a few words a lucid interpretation of the topic at hand.

I once asked Förster how to grade a thesis paper, and he advised me to be not too strict. But for him, Theodor Förster, his scientific work had to meet the highest standards. Things had to be correct, of course, but equally important: it had to include the most concise analysis of the problem, a perfect logic of the solution, and a clear statement on the significance of the results. He did not publish much, but the things he did publish can be a source of inspiration still today.

Figure 1.4

You may know that the phenomenon of fluorescence depolarization was an important step that ultimately led to an understanding of electronic excitation energy transfer between molecules. After a large amount of empirical material had been accumulated by others, Förster, in a lucidly written review article, gave a brilliant analysis of this effect and brought a long discussion ultimately to an end. Thus, may I advice you, once in a while, to take your time off from the lab and go to the library and study a paper of his, or better still his most admirable monograph "Fluoreszenz organischer Verbindungen." You may be rewarded by getting a hint on how problems may be solved by putting them in the right perspective, a strategy in which Theodor Förster was a superb master.

My picture of Förster would be incomplete without remembering how much he enjoyed the company of colleagues, or of his students, for example, at a Christmas party in the lab (Figure 1.5).

Very often prominent colleagues from abroad came to Stuttgart, gave a talk, and certainly were invited by him and his wife Martha (Figure 1.6) to their home. Regularly, younger members of the department were also invited to these evenings.

For me, certainly the most memorable of these meetings was when James Franck visited Stuttgart, I think in 1964 (Figure 1.6). You all will know the fundamental work in atomic physics done in Berlin and Göttingen by Franck and Hertz in the 1920s, or the direct proof of a radiationless energy transfer between atomic systems by Franck

Figure 1.5

and Cario. But I think we should also remember that James Franck was the initiator of the Franck Report of 1945.

In the last picture (Figure 1.7), you see James Franck and Theodor Förster many years after the war, evidently discussing at a scientific conference. Also the topic of their discussion was – I am pretty sure, – the phenomenon of light harvesting, energy transfer, and photosynthesis, questions that fascinated both these men for many years. Franck gave the first experimental proof that the electronic energy may be exchanged radiationlessly among atoms, and Förster, some 25 years later, on the basis of his deep understanding of quantum mechanics, gave us the theory of the

Figure 1.6

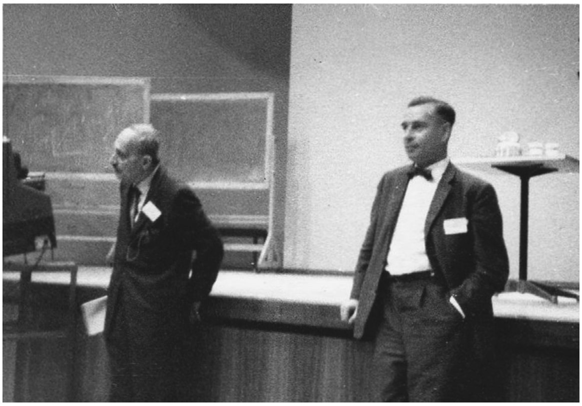

Figure 1.7

nontrivial transfer of electronic energy in molecular systems, the “Förster resonance energy transfer” (FRET), which gave us a formula that has become extremely important in biological sciences.

The contributions of Theodor Förster to modern photochemistry are most impressive, but equally fascinating to me is the way in which he elaborated these things. If you have a look at his strategy, I am certain you will have a good chance to profit also from this aspect of the work of Theodor Förster.