Richard Ernst (1933–2021)

Richard Robert Ernst, born on August 14th 1933, passed away on June 4th 2021 at the age of 87 in his home town of Winterthur, of which he was a honorary citizen. He developed Fourier transform NMR spectroscopy together with Weston Anderson working for the company Varian, and later extended this to two- and higher-dimensional NMR spectroscopy. His work laid the foundations for present-day use of NMR spectroscopy as a universal tool to investigate materials and chemically or biologically relevant molecules. The structure and dynamics of proteins and oligonucleotides, and the development of pharmaceuticals via the determination of drug/target complexes, provide some examples of present-day topics that could not be investigated without his contributions. The introduction of Fourier transformations was essential to establish magnetic resonance imaging (MRI) as an alternative to X-ray based computer tomography. For his methodological developments, Richard Ernst (Figure 1) was awarded the Nobel prize for chemistry in 1991.

Richard Ernst developed an interest in chemistry in his youth and installed a laboratory to carry out experiments in his parental home where he was brought up. He studied chemistry at ETH Zürich beginning in 1952, and completed his PhD under the supervision of Hans Primas on stochastic NMR spectroscopy and the optimization of NMR spectrometers. During this time, he established contacts with Trüb Täuber AG, which was later bought by Bruker Inc. After his PhD he strived to contribute to practical applications and joined the company Varian Associates in Palo Alto, California. Ernst published in 1966 a paper about the principles of pulsed excitation combined with Fourier transformation. This was soon to replace the "continuous wave" approach where individual resonance lines are excited sequentially by a weak radio-frequency irradiation that is slowly swept through the spectrum. By using pulsed excitation, all resonances can be excited simultaneously by a short broad-band pulse, before recording the time-dependent free induction decay (FID). The publication in 1966 in the *Review of Scientific Instruments* shows an increase in sensitivity by a factor of 10. Applications of the same method combined with broad-band proton decoupling resulted in a 100-fold increase in sensitivity. The next milestone was the development of two-dimensional NMR spectroscopy based on an idea presented in 1971 by the Belgian physicist Jean Jeener at a summer school in Yugoslavia. In this experiment, an evolution time t_1 separating two radiofrequency pulses is incremented, in addition to the t_2 time used for detection. The experimental implementation and conceptual advances were summarized in 1976 in an important publication in *Journal of Chemical Physics*, which gave a detailed analysis of homonuclear correlation experiments. These experiments remain until today the basis for structure elucidation of molecules by NMR spectroscopy. Richard Ernst also applied the 2D principle to EXchange SpectroscopY (EXSY) to measure slow exchange phenomena. EXSY and NOESY are based on the same pulse sequence; the latter can reveal spatial proximities between hydrogen atoms via the nuclear Overhauser effect (NOE). The first applications of this approach to proteins were published in 1980 in collaboration with Kurt Wüthrich and

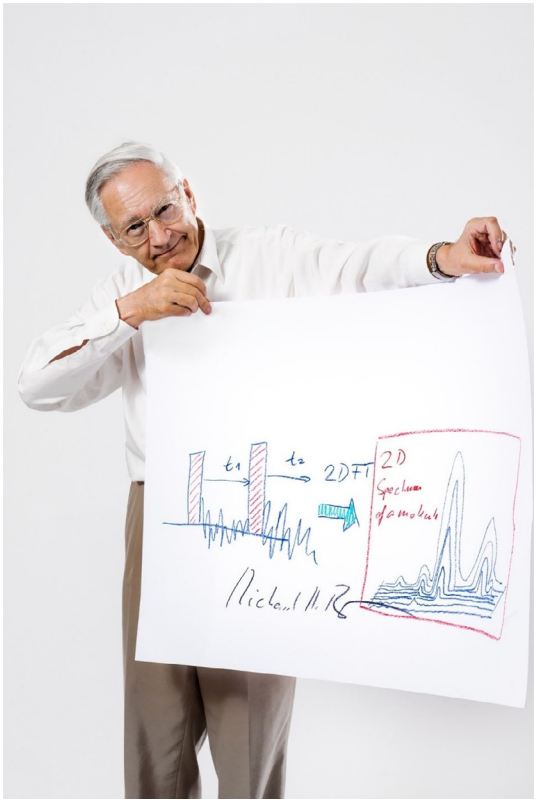

Figure 1. Richard Ernst explaining the concept of two-dimensional NMR spectroscopy. Source: Mediatheque of the Lindau Nobel Laureate Meetings.

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still constitute the basis for structure determination of biomolecules such as proteins and oligonucleotides.

Richard Ernst was a master of lucid and accessible lectures and developed conceptual tools such as product operators which allowed many research groups to apply multidimensional NMR spectroscopy to their research. Richard Ernst's intellectual honesty and his deep insights provided a role model for many of his students and postdocs, many of whom are now professors in the fields of NMR spectroscopy in liquid and solid phases. Before the Nobel prize, Richard Ernst received the Marcel Benoist prize in 1986, and the Wolf and Horwitz prizes in 1991.

In addition to his research, Richard Ernst was engaged as scientific advisor of the company Bruker, whose rise to world leader of NMR spectrometers he accompanied during his PhD and later in the 1970's. He also took on tasks in scientific administration as president of the ETH Research Commission and for the Swiss Research Council. Music and Tibetan art were leisure activities that provided a balance for his devotion for science. He constituted an impressive private collection of Thangkas and Mongolian paintings and investigated the pigments used in these works of art after his retirement in 1998. Even at an advanced age, Richard's lectures encouraged researchers to take responsibility in society and to work for a better world. His last scientific publications are entitled: *Heading towards a better world. Part 1: wisdom, compassion, and personal responsibility* and *Part 2: the current world situation and the responsibility of universities*. His recently published self-critical autobiography describes his personal and scientific life with great openness. Richard is survived by his wife Magdalena, who was his support and companion in life since 1963, and three children.

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