*Kai Siegbahn was born in 1918 in Lund and following his Bachaloria, studied physics mathematics and chemistry at Uppsala, graduating in Stockholm. From 1942 until 1951 he was at the Nobel Institute for Physics and then Professor of Physics at the Royal Institute of Technology, Stockholm. Since 1954 he has been Professor and Head of the Physics Department at the University of Uppsala. He is an Individual Member of the European Physical Society.*

# 1981 Nobel Prizes in Physics
# Kai Siegbahn

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It is commonplace to remark that chemists invariably take advantage of, and rejoice in, the discoveries of the physicist: this thought springs to mind with the announcement of the 1981 Nobel prizewinners in physics, especially in regard to the sustained contributions of Kai Siegbahn. To appreciate fully the pleasure that chemists derive from Siegbahn's award, it is instructive to recall that seminal era — the first few decades of this century — when both the fundamentals of quantum mechanics and developments pertaining to X-rays occupied the thoughts of many physical scientists.

Well before Manne Siegbahn (father of Kai) was awarded his Nobel Prize in 1924, the Braggs and others had divined what could be accomplished by X-ray diffraction. So remarkable have been the achievments of X-ray crystallography in subsequent years, there is a tendency amongst chemists and biologists to talk of "X-ray spectrograms" when what is really meant are "X-ray diffractograms". The subconscious belief, one supposes, is that the X-ray region of the electromagnetic spectrum yields its information upon structure spectroscopically, just as do the UV visible, IR and microwave regions. Manne Siegbahn and others, notably Skinner, had however, demonstrated what genuine X-ray spectroscopy entailed and what it could achieve. For many decades, X-ray spectroscopy was the principal technique for experimentally determining the band structures of solids, as well as for establishing the quantitative values of the electron energy levels of atoms and molecules.

When X-rays impinge upon matter, not only may they be diffracted or absorbed, they may also liberate electrons, the kinetic energies of which are equal to the difference between the energy of the incoming photon and the binding energy of the emitted electron. Robinson[1,2]), de Broglie[3]) and Willams[4]), as well as others, had turned their attention to this phenomenon of X-ray induced photoelectric emission in the second and third decades of this century. Robinson, in an elegant publication in 1925, described how he recorded, photographically, the X-ray induced photoelectron spectrum of gold. Although several subshells in the M and N shells of gold could be identified in the photometric recording of his photographic plate, the resolution was insufficient to distinguish all subshells and a true line spectrum was not obtained. This was the beginning of electron spectroscopy. But its potential remained untapped, its promise unfulfilled, for more than thirty years; and it is conceivable that this branch of high energy spectroscopy would still be lying dormant had not Kai Siegbahn initiated, in 1951, a research programme aimed at the very high resolution study of the energy spectrum of electrons expelled by X-rays.

When the fruits of Siegbahn's labours first appeared in the late sixties, their impact, especially upon physical chemists and chemical physicists, was immediate and compelling. It has been argued that the publication of "ESCA — Atomic Molecular and Solid State Structure Studied by Means of Electron Spectroscopy" [(Siegbahn K. *et al.*), *Nova Acta Regiae, Soc. Sci. Uppsaliensis* Ser IV, Vol. 20 (1967)] marked a turning point, not only in the course of spectroscopy, but also in the activities and aspirations of many experimentally and theoretically oriented scientists. The excitement that it caused has been likened to that aroused amongst chemists by Pauling's Fischer-Baker Lectures "The Nature of the Chemical Bond", and amongst physicists by Mott and Gurney's "Electronic Processes in Ionic Crystals".

*ESCA — Electron Spectroscopy for Chemical Analysis* — as the book was first designated, overwhelmed the reader by its precision, breadth, execution and promise. In the preface, Siegbahn *et al.* soberly announced that the work they had commenced in the early fifties on electron spectroscopy was (in 1967) "ready for a more general use". "The energies that can be measured by our present equipment range from 1 MeV down to 0.01 eV, i.e. 26 octaves". In the body of their text, they proceeded from one coruscating example to another to demonstrate how high energy photoelectron spectroscopy could be utilized to great advantage. The presence of any element from lithium to plutonium could be detected by its characteristic electron spectroscopic fingerprint. From a knowledge of photo-electric cross-sections and escape depths (for solid samples) quantitative chemical analyses could be undertaken. Band structures of solids could be recorded more straightforwardly than hitherto. Chemical shift information relating to "characteristic" binding energies of certain electron energy levels were shown to be dependent upon atomic environment and charge density, both of which could, therefore, be probed using this new spectroscopic tool. Auger electrons, and Auger transitions, could be immediately identified, and in favourable circumstances, especially for free molecules [see Siegbahn K. *et al. ESCA Applied to Free Molecules,* (North-Holland, Amsterdam-London) 1969], vibrational fine structure of Auger electron lines could be characterized, and the direct consequence of phenomena such as autoionization, electron-energy-loss, shake-off and shake-up ascertained.

Siegbahn's work fired the imagination of a whole generation of scientists. His work has demonstrated how a concern for accuracy and meticulous attention to experimental detail coupled to a broad vision and scientific sure-footedness can open up new chapters in scientific endeavour.

Many of the new techniques and experiments currently appearing in the fields of surface, semiconductor and polymer science can trace their lineage to Siegbahn's pioneering work. It was not until 1970, for example — and not until Siegbahn's experiments using multilayers of α-iodostearic and DL-α-bromostearic acids had been fully appreciated — that monolayer amounts of adsorbed species on single-crystal solid surfaces were first detected by electron spectroscopy. Nowadays, less than a hundredth of a monolayer of adsorbed species on a crystal of area less than 1 cm$^2$ may be detected in this way, and, with the aid of angle-resolved measurements, the symmetry properties of orbitals or adatom sites may also be ascertained. With the advent of synchrotron radiation many of the experiments adumbrated and already executed by Siegbahn and his contemporaries in electron spectroscopy can be extended in directions which require no further elaboration here.

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