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Is analytical chemistry a self-generating science or depending upon problems and ideas from other scientific areas?

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Summary. Some aspects on the situation of analytical chemistry as science are presented. Two examples can illustrate the influence of other sciences on the progress of analytical chemistry.

In the development of modern analytical chemistry we can recognize the difficulty to keep up a front research level without a high degree of specialization. An autonomous academic community in analytical chemistry must at the same time be able to possess an educational program of much broader dimension, even if it is not covered by own research. Furthermore, it is obvious that today bioanalytical chemistry including advanced separation techniques, immunology etc. can with advantage be handed over to the scientific sectors where the problems are located and where analytical methods currently are in use. Also analytical chemistry in medicine has expanded in specialized units because of certain technological problems connected with a high degree of automation, computerized laboratories, which is a function of the demand for many and rapid analyses.

The concept of analysis is in many ways connected to reality. As a consequence it may be a stimulation also for inorganic or organic chemistry to give the research activities a specific analytical chemical profile. Heavy and expensive intrumentation can be available in the respective departments, convenient for applied analytical problems. In the long run, it can create a dilemma for analytical chemistry – will the dominating area comprise only techniques or to an increasing extent be linked to real and applied problems?

In Sweden full professorships in analytical chemistry were created at all universities in the 1960's. In addition, chairs at the technical and pharmaceutical faculties were established with their own departments or institutes in equivalence to the other chemical disciplines.

The original intention was to consolidate a qualified education of analytical chemists especially for the industry where the demand is high. It has been possible to redeem the expectations of an education of good quality and nearly sufficient in number. However, some problems are discernible. One problem is the difficulty to maintain an educational standard with instrumental facilities on the level with industry. As an example, we have at Pharmacia in Uppsala a high demand for analytical chemists, which is fortunate but also renders the continuity in the institutional research projects more difficult. Collaboration with the industry or their scientific disciplines represent alternative possibilities. More often incidental contacts can be of great benefit for partners involved. Any philosophy can predict a future for analytical chemistry, but according to our opinion difficulties increase in a more complex scientific world where new analytical chemical concepts frequently appear.

Who or what is forcing the development in analytical chemistry? To a less extent the analytical chemists themselves. Let us look upon two relatively recent examples. In the 1960's Kai Siegbahn and co-workers introduced the electron spectroscopic technique which they named ESCA [1]. This stands for Electron Spectroscopy for Chemical Analysis. The word Analysis is perhaps included on account of the successful attempts in the beginning to measure so-called chemical shifts. Today ESCA is a well established technique with applications in many fields of science, e.g. surface investigation, but the terminological connection with analysis remains. Anyhow, this is a modern example of the great impact that physics always have had on chemistry and specificly analytical chemistry.

Another example, perhaps more interesting, is represented by Henrik Lundegårdh and his contribution to the development of the flame spectroscopic analysis. In fact, this was intended to be the main point of this presentation. In "A History of Analytical Chemistry" [2] attention is called to the fact that "the modern era of flame photometry begins with the familiar name Lundegårdh". After a comprehensive report about Lundegårdh's achievements in spectral analytical chemistry is notified that everything comes from this man whose primary interest was plant physiology! It is further remarkable that Lundegårdh is much more well-known abroad than in his home country, because his profession was not in chemistry.

Some biographic notes are impressive. He was born in 1888. He began his academic studies in Stockholm and already in 1912 he had passed all exams and was appointed senior lecturer in botany the same year! His thesis was far ahead of its time, consisting of eight papers (500 pages) all written in German. Lundegårdh's innovative talent and artistic imagination was merged in botany. For over 60 years his main research field was the plant roots and the combina-

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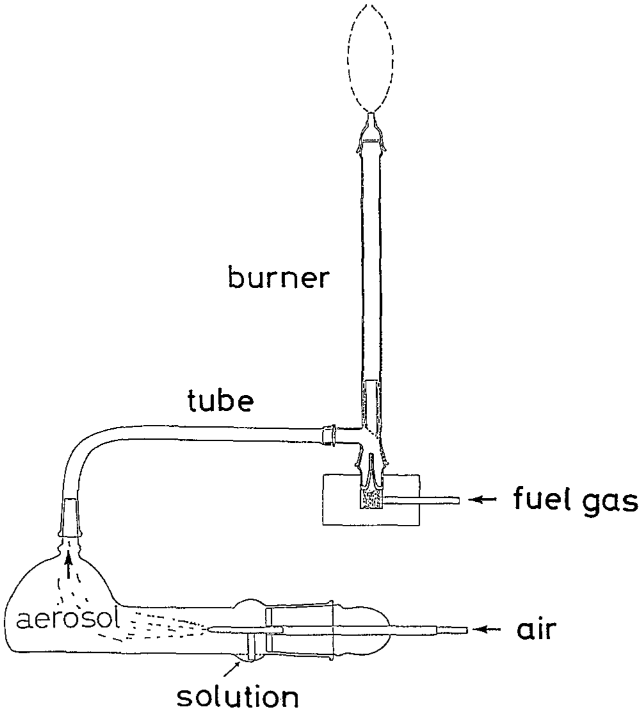

Fig. 1. Nebulizer developed by Lundegårdh in 1928

tion of the nutritive substances in soil and the essentials for plant material. His in many respects pioneering research was not accepted in the beginning and it was not until 1926 that he obtained a permanent chair in the botanic department at a research station near Stockholm. In a completely empty laboratory he started to build up a research activity, constructed smaller laboratory equipment and began to study spectral physics on his own. Lundegårdh constructed the first usable instrumentation for quantitative analysis based on emission spectrography in flame. He used a premixed air-acetylene flame, pneumatic nebulizer sample introduction and photographic detection. Figure 1 shows the burner he used, essentially the same design as can be found in the modern atomic absorption instruments. His initial work was performed on a medium quartz spectrograph of Twyman's type, but he eventually developed a completely automated system that changed film, controlled the exposure, developed the exposed film and recorded a microphotometer tracing of the spectral lines. Lundegårdh also developed the spark-in-flame method in which a condensed spark discharge was passed through the flame to enhance excitation of some elements.

Three years after he had entered the empty laboratory he published the books "Die quantitative Spektralanalyse der Elemente", volume I in 1929 and volume II in 1934 [3]. In these books Lundegårdh reviews the periodic table with information about useful spectral lines, both for spark and arc. His research brought him in contact with scientists all over the world working in quite different fields such as plant physiology, forestry, soil science, medicine and archeology. Remarkable is his talent to establish criteria for accuracy, precision etc. in his methodological work. Lundegårdh died in 1969 and was during his whole life in the front of research emphasizing innovation as essential. Some of his most brilliant and important work in plant physiology appeared during the last ten years of his life.

It can be objected to that Lundegårdh with his conspicious appearance in analytical chemistry represents a famous exception. Nevertheless, it illustrates in a pronounced way the importance of the connection to real objects as an inspiration for new developments in analytical chemistry. As an answer to the question in the title of this contribution we already face the difficulty for small educational units in analytical chemistry to maintain a position in the front of research. The instrumental development is in general very accelerated and to a large extent commanded by commercial business. On the other hand, we are of the opinion that a modern education in analytical chemistry must be taken care of by a team of professionals well trained in this area.

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