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THE CHEMIST FACING THE STRUCTURAL CHANGES IN THE CHEMICAL INDUSTRY*

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INTRODUCTION

The significance and the image of the chemical industry and the position, the mission, and the professional perspectives of the chemist have experienced significant changes over time. There were continual changes from the medieval alchemist, a magician searching for gold and immortality, the scientists of the early 19th century creating the modern sciences and striving to understand and control the elements and the processes of life to the chemists of a hundred years ago who produced the first manmade dyestuffs on a large scale. The beginning of medicinal chemistry in the 1920s, the increasing knowledge and understanding of chemical reactions, and the new material sciences resulted again in a change of the position and the possibilities of the chemist and the scope, structure, and environment of the chemical industry. The increasing knowledge about biological processes, the growing relevance of biochemistry, and the rapid developments in the field of genetics, in data management, and information technology have had again a remarkable impact on the role and the situation of the chemist.

In all these different eras there was a common feature to the image of the chemist: For people who are not familiar with the profession there existed always somewhat unclear and sometimes unrealistic notions about the activities, possibilities, limitations, and the power of the chemist.

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The working environment for the chemist, the mission and working conditions have also experienced important changes during the past few decades. The chemist in industry of the first half of this century was either working in a research laboratory at the bench or in chemical production. In either case he was working in isolation with little communication and almost no flow of information across the organization. The business was technology driven, chemical research and manufacturing were the core competencies of the company and Production had a preferred central position.

Since the 1950s the pharmaceutical/chemical industry became more and more market driven. New and innovative products had to be developed and manufactured to satisfy customers. A good integration of R & D projects in the business strategy is important to manage the innovation process successfully.

In the same period the knowledge and understanding of biological and biochemical processes were increasing in scope and in depth at a rapid pace, leading to a stronger influence and position (*Stellenwert*) of biosciences in the discovery and development process. In manufacturing the efforts to improve the production processes were extended from optimizing the cost of production to improving safety and ecological parameters at the same time. All these trends were leading away from the working approach of the isolated chemist to an interdisciplinary working environment, to the team approach and an open communication across boundaries of departments, disciplines, and locations.

For the chemist these developments mean above all that there is no special status for him as a scientist and that he has to be able and willing to work in interdisciplinary teams. He contributes with his basic and specialized knowledge in the interdisciplinary team in which – ideally – all of the relevant disciplines are represented.

There are two major areas through which the chemist in industry can proceed and where chemists can contribute value to the respective company:

– In the area of life sciences the chemist integrates his knowledge with the knowledge of biologists and other specialists in medicine or animal and plant sciences.

– The second avenue for chemists leads towards engineering, mechanical, electrical, and physical sciences. The vast field of material sciences offers many opportunities and challenges for innovation. There is a need for new materials like composites, ceramics, additives for textiles and plastics, intermediates and catalysts for manufacturing, as well as for new analytical methods, chemical sensors, and optoelectronic devices.

It is in this environment of changes that we are asking ourselves how the environment will impact on the chemist's future role. I will sketch some of the important changes taking place in industry in the areas of the economic, the social, and the technological/scientific environment and in a second part I shall try to analyse the consequences and challenges such changes impose on the chemist of the future. My thoughts relate mostly to the Life Sciences Industry.

CHANGES IN THE ECONOMIC ENVIRONMENT

The economic environment of the chemical industry is influenced primarily through the globalization of the markets and the increasing competitive pressure. Through networks of trade and information all major products and services are today offered world-wide and the competitive edge of many products is determined by the ability to differentiate them in performance or price. Companies determined to prevail in this competitive situation have to anticipate the world markets.

There exist no longer any traditional home markets which determine the product range of the industry. Home markets have the same rules as the global markets. This also means that the preferred locations for marketing organizations and technical operations will be determined by strategic factors, the availability of resources, the social and legal environment, and the proximity to the customers.

The players in the global markets have to adjust their structures and locations and they must re-focus their activities in view of their competitive advantage. This leads to an increasing concentration of the industry by mergers and acquisitions, as we are experiencing ourselves. The companies have to exploit their synergy potential through management effectiveness, rationalization, and through focusing on core competencies. Outsourced segments offer, for instance, many opportunities for small, for highly specialised, or for start-up companies.

We observe a dramatic increase of cost for innovation and the expectations and pressures of the financial community.

Another source of changes, particularly affecting the pharmaceutical industry, can be described as the "power shift" of customers. Traditionally the medical doctor has decided and prescribed the therapy and the medication for his patients. The decision power now shifts more and more towards the payer, the health insurance companies and the patient. This shift influences the marketing strategies, the organizational structures, the product range, and the supply concept in the pharmaceutical industry.

The internal technical and commercial resources of the chemical industry are increasingly focused on segments with high value added potential and on product innovation and improvement. The Swiss import/export ratio of chemicals illustrates the importance of added value. In 1996 Switzerland imported chemical products for 13.5 billion Swiss francs (CHF), compared to exports of almost twice that amount (26 billion); according to SGCI the average cost of imports was about CHF 3.5 per kilogram, whereas the average price of exported chemicals was about CHF 17, a fivefold increase in value. It has to be noticed that the value added segments are more and more shifting from the producer to the creator of ideas and innovations. A strong process and product innovation effort is therefore the crucial factor for long-term success in maintaining a position in the high added value segment of any business. Consequently the research and development activities of the chemical industry are increasing in absolute terms as well as in percentage of sales.

CHANGES IN SCIENCE AND TECHNOLOGY

The developments and ongoing changes in science and technology are among the most striking and highly visible changes taking place in our industry. There were never so many people with such a high level of knowledge and never was communication of results and data so thorough and so easy. Information technology and computer power facilitates most tasks of the chemist and enables the progress in areas like gene technology, testing methodology, and data handling. As a result the disciplines of chemistry, biology, and medicine are moving closer together and the traditional gaps between the disciplines are being closed.

Biotechnology, molecular biology and its application in gene technology are broadening the scope of the tools available in life sciences. They are complementing, not replacing, the range of presently available methods and products in the areas of health care, plant breeding, and crop protection. The full impact of methods like somatic gene therapy and xenotransplantation is not foreseeable yet; however, we have to be prepared to stay at the forefront of the development of such emerging technologies.

New technologies are also developing in non-biological sciences. In the field of material sciences new light weight materials with improved mechanical and heat stability properties are being developed. New supramolecular structures are being investigated, which exhibit unusual optical, optoelectronic, and magnetic properties useful for data storage and other electronic or optical devices. Research in catalysis, especially in stereoselective reactions, has made great progress in the past few years and opens new possibilities for ecologically improved manufacturing processes. New territory is also explored in the research of energy storage and molecular batteries, in sensor technology and analytical/diagnostic tools.

Obvious examples of multidisciplinary techniques are the new approaches in synthesis and testing large libraries of compounds, the computational and combinatorial chemistry, and high throughput screening. These are methods and approaches to new products that are possible only as a result of combining biological, medicinal, and chemical knowledge with know-how in computer technology.

CHANGES IN THE SOCIAL ENVIRONMENT

A recent study by the German Institute for Economic Research (DIW) has confirmed a clear pattern of the internationalization of the industry: the sites for industrial manufacturing follow the customer, the key markets. Sooner or later research and development will follow. Besides the economic parameters several legal and social factors like social stability and acceptance of scientific progress and new technologies influence the selection of production and R & D sites. The social changes taking place in Europe today are characterized by reluctance to accept the activities of the chemical industry, including technologies like genetic engineering, the necessity to experiment with living organisms, and the need for a thorough coverage of intellectual property protection.

The image of the chemical industry and of the profession of the chemist in the public has an impact on the availability of employees, the attractiveness of natural sciences for students and the education system. A sound education system that stimulates the interest of students in the humanistic area as well as in the science field is of great importance for the education of future employees for our industry. Teaching science subjects at secondary school level is a must for a country that wants to host chemical/pharmaceutical industries. Excellence in teaching from high school to universities and in basic research at university level has stimulating effects and fosters the formation of well trained chemists whom the industry will also need in the future.

Among the social changes we have also to mention some ongoing changes in legislation. Government activities and industry efforts should be complementary. Legislation should stimulate progress and investments and not restrict them. Initiatives like those being launched in Switzerland to forbid the use of some technologies are restricting the development in the country. An attractive country for an innovative industry has to provide an innovation friendly environment with a positive attitude towards new technologies. This includes practicable legislation in the areas of ecology, animal rights, gene technology and permits for construction and operation of pilot plants.

The social responsibility of the enterprises in all decisions, on the other hand, is also a precious good. The chemical industry is executing important personnel matters in close co-operation with their social partners. Permanent training and additional education are provided by the firms and are considered as an important social contribution. Broad training and flexibility of the employees help to reduce or to avoid terminations and lay-offs in the course of industrial restructuring processes.

CONSEQUENCES FOR THE POSITION OF THE CHEMIST

I want to discuss now a few implications these changing economic, structural, and social parameters have on the situation of the chemist in the industrial environment.

Economic environment

Among the economic changes taking place in our business it is the globalization of the markets that will have the most significant impact on the situation of the chemists. Traditionally the chemical industry has built on products protected by their quality standards and intellectual property protection law. It has measured the world markets with local standards and has manufactured its products close to the home base. The globalization is leading to an increased competitive pressure not only for the best and most cost effective products, but also for participating in the most attractive markets. This means that some production and R & D sites will be transferred to new sites and locations. These transfers require from the chemists **flexibility, mobility**, and **an open mind for opportunities** and **trends**. The industry needs **chemists with leadership qualities** who are flexible and prepared to move to new assignments, activities, and geographical areas; people with a **sound basic knowledge of their professional field** and the ability to see the entire picture of the business.

The ongoing structural changes in the pharmaceutical/chemical industry have not only the objective to increase shareholder value, they are essential to realize synergies, to achieve more presence and weight in the market places, and to reach a critical mass for the innovation potential. The pharmaceutical R & D budget of Novartis, for example, is about CHF 2.3 billion. Together with partnerships and strategic alliances with research based third parties, the Pharma Sector reaches the critical mass which allows it to innovate the product range in such a way that the long-term presence of the company at the forefront of the industry is assured. Chemists and other scientists in this R & D environment have to understand the driving forces of the markets and the dynamics of the business. They must be capable to **translate market needs into R & D programs and projects** and they must have the ability to explain what they are doing in generally understandable terms.

While some big companies, like for example the automotive industry in the USA, reduce their size and structures, many existing positions are substituted. Several activities and services, production of parts and manufacturing of intermediates are outsourced, which creates new opportunities for start-up companies, as can be demonstrated by the figures of the US industry. During the period 1993–95 the large US concerns eliminated 3.6 million jobs. At the same time 5.0 million new positions were created by small and start-up companies. The chemical industry is subject to the same changes and for this process needs scientists with **entrepreneurial qualities** and **economic thinking**.

Social factors

Unclear notions about the profession of the chemist lead to a lack of social acceptance of and confidence into the chemical industry and the profession of the chemist. The uncertainty about the potential of new technologies like gene technology, unclear and misleading information create a certain uneasiness and even fear in the public and add to a low level of acceptance of natural sciences.

Companies have the responsibility to create a sense of purpose and a vision that provide a direction for the scientists.

As a result of these critical views and the present tight job situation in the European chemical industry, the number of chemistry students in Europe has significantly declined during the past few years. As a consequence of these developments the public funds for research and teaching in chemistry are also decreasing (universities, national funds) and we have to make real efforts to maintain the high scientific standards that make Switzerland an attractive country for the chemical/pharmaceutical industry. Many respectable colleagues predict a significantly increased requirement for chemists in 5 to 10 years.

Science and technologies

New technologies, above all **information technology** and **molecular biology** and their application in **genetic engineering**, have changed the working environment of the industrial chemist. The new technologies are complementary to the traditional field of chemistry and they provide new challenges and opportunities for chemists in the chemical–biological direction as well as in the area of chemical engineering, production, and material sciences. We understand the basic chemistry of biological processes more and more and we are able to describe biological mechanisms in chemical terms. Our knowledge of materials and of molecular and supramolecular structures is rapidly increasing and we generate a flood of data, which have to be handled by electronic means.

Information technology has changed the working environment of many professions, including chemists. Handling literature and patent searches, managing data, accessing data banks, searching and designing new active principles, and process control are a few important applications, requiring **knowledge** and **command of electronic tools**.

The increasing complexity of the subjects requires a working approach with **interdisciplinary teams**. The individual members of the teams contribute with their **basic** and **specialized knowledge** and their **understanding of the areas of application** of their disciplines. The chemical industry will therefore need chemists who are **able to manage** and **to contribute to interdisciplinary teams** and processes in the areas of chemistry and engineering and in biosciences. Chemists have generally good access to other disciplines and to an interdisciplinary working environment. They have to be trained even more to approach the tasks and problems as **team players**.

In the recent survey by your Association (NSCG) several managers confirmed these statements and they emphasized that also medium-size and start-up companies that are focused on biotechnology research will employ increasing numbers of chemists, because the majority of future drugs will be synthetic products. The exact figures of open positions for chemists in the chemical industry for the next few years are not known presently, the SGCI has initiated a survey to study the future need for chemists in the Swiss industry. It is important to note that the new technologies may cause restructuring and re-focusing of industrial functions and sectors, but they will cause a substitution rather than a reduction in positions and jobs for scientists.

The education and the training of the new generation of chemists have to be adapted to the requirements of a **sound knowledge of the basic chemistry**, the **understanding of the areas of application**, the management and working habit of **interdisciplinary teams**, and the **understanding of the basic economic principles**.

Education and universities

In the course of the "Third International Mathematics and Science Study" about half a million students aged 14 from 28 countries were tested in mathematics and natural sciences and their results were ranked. The Swiss students ended at rank 8 in mathematics, but only at rank 18 in natural sciences. This is an alarming result, whatever the reasons may be, large classes, few hours of teaching natural sciences, lack of interest of the teachers, or lack of learning pressure. The Swiss authorities, the Department of Education, the Cantons and their bodies should take actions for improving this situation.

The public education system, particularly at university level, is of fundamental importance for preparing chemists for their industry position. At universities and institutes of technology teaching and research belong close together. Unfortunately, some professors focus their entire interest on their research and consider teaching a nuisance and a burden. Let me state very clearly that the chemical industry considers teaching as the primary mission of universities. High quality research is a good and sound base for excellence in teaching. We expect that chemists receive a first class, diversified education that prepares them for different positions in industry and gives them a high degree of flexibility in their choice of positions. Universities have to abandon the idea to prepare chemists exclusively for their professional position as researchers. Teaching schedules should also include basics in law, economics, communication, and social topics. These topics should be integrated into the regular schedule for students without extending the present time for studying chemistry.

CONCLUSIONS

In conclusion I am convinced that the position and the professional profile of the chemist in today's chemical industry are subject to an evolution as markets, industrial structures, and technologies are changing. The requirement for **well educated**, **versatile**, and **flexible chemists** in different business areas is high. The future scientists will need the ability to **work in interdisciplinary teams** and have well trained social and communication skills. Familiarity with the **applications of information technology** and the potential **of processes in biotechnology** and **engineering sciences** is essential.

Interest in and enthusiasm for science subjects are generated at primary and high school level. The situation in many countries and certainly in Switzerland is mediocre and needs to be improved. It is an important task for the professional organizations and the chemical industry to provide open information about the attractiveness and beneficial contributions of the profession and the future need for chemists.

The chemical industry will continue to engage in dialogues with the public, with authorities, and school in order to improve the image and knowledge about the merits of the industry and the profession of the chemist. The industry will also continue to support the education of chemists at the educational institutions by common projects and co-operation, by sponsoring scholarships, and by engaging members of academic institutions as consultants. We are optimistic that the universities will succeed in adapting their teaching agendas to the needs of today and the future in such a way that chemists will be sufficiently prepared to meet their challenges and to adequately fill the positions needed by the chemical industry in the future.