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Commentary
Chemists of the Future

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The chemical industry is one of the most important economic sectors in Europe and particularly in Germany. This will presumably remain so in the future. In the aftermath of the recent commercial crisis, now more than ever there will be a greater demand on the chemical industry to be increasingly efficient and innovative. Many of the global challenges can only be addressed successfully by applying chemistry. Some the most important areas in which chemistry will play an integral part in the future include better medicine, food for a growing population, provision of sustainable energy, mobility, and clothing. Accordingly, chemical production will remain at high levels as will chemical research. This follows as innovative chemistry is a prerequisite for creating the necessary chemical products and chemical answers to these challenges.

Hence, chemists working in research play a key role for future life on earth and will continue to do so. We have learned from several environmental problems during the last few decades that chemistry is often considered by the broader public as a problem maker. However, it undoubtedly has the potential to change this misconception and can be seen in a much more positive light as a problem solver. One example of this is in the field of chemical sustainability. Here, the focus is not solely directed at solving problems associated with chemical production and the related products (e.g. waste water treatment, dioxine-free production, or coatings free of organic solvents, all of which could be considered under the umbrella of Green Chemistry), but also at supporting other branches, social fields, and groups, or other research disciplines with the necessary chemical know-how to achieve more sustainability (e.g. in energy supply).

Let us now focus on the energy issue. This is truly an interdisciplinary issue as we need to address the potential dramatic shortfall in the global energy supply in the not too distant future. Engineers, physicists, biologists as well as chemists (of course) are involved. All of these scientists will have to intensify their cooperation, in academia as well as in industry. The contribution of chemistry to future energy supplies is manifold: The provision of fuels from crude oil, natural gas, coal, and biomass, the production and storage of hydrogen as a contribution to the hydrogen economy, the generation of energy from sunlight, the development of fuel cell technology, of new types of batteries, and supercaps, the provision of thermoelectric devices, of materials for collectors, and for superconductors, of luminescent materials, for example, for light-emitting diodes, of lightweight materials, and nanoporous foams. All of these diverse fields reflect innovations from chemistry at their core. Chemists and engineers will also continue to enhance the energy efficiency of chemical production processes and the development of power plant technologies.

To meet these challenges, we need traditionally educated chemists with a fundamental background in inorganic, organic, and physical chemistry whether they ultimately work as electrochemists, photo chemists, chemical engineers, polymer chemists, solid-state chemists, or in other areas of chemistry. Modern Master Programs at our universities are increasingly becoming specialized and offer many options for an interdisciplinary education. This leads us to the question whether a chemist (with a Bachelor degree) is still a chemist after he or she has received a Master degree in a major such as “Hydrogen Technology” or “Renewable Energies”, which a first sight might seem relatively distant from “chemistry”. Admittedly, we have to anticipate new job titles

for scientists and engineers now and in the future (such as material scientist, nanostructure scientist, or environmental scientist). Nevertheless, a chemist remains a chemist, when he has received the degree of a Bachelor of Science in Chemistry or when he is working on chemical issues.

For example, the Nobel Laureate in Chemistry in 2007, Gerhard Ertl, studied physics. He needed more than merely a foundation in physics for his chemical research on surface processes that are important for understanding the mode of operation of catalysts. Ertl, the physicist, worked as a chemist; thus he is both. This combined approach to physics and chemistry is certainly not new. After all, physical chemistry (as the chemists call it) or chemical physics (as the physicists call it) is one of the classical pillars of chemistry. Accordingly, many other similar interdisciplinary developments can also be expected in related fields.

Chemists need to learn more than just the fundamentals of biochemistry, biotechnology, and biology, not only for converting biomass into fuels and platform chemicals but also for promoting progress in medicine, pharmacy, and agriculture. Extensive knowledge in biochemistry and white, red, and green biotechnology are currently revolutionizing anthropogenic conversion processes of matter with great potential for the future. Nonetheless, it is essential to simultaneously preserve the classical core competences in chemistry.

The future belongs to the chemical and molecular sciences! This is one of the reasons why the Federation of European Chemical Societies in 2004 changed its name to the European Association for Chemical and Molecular Sciences (EuCheMS). Similarly, at the national level, the Gesellschaft Deutscher Chemiker (GDCh, German Chemical Society) regularly points out that it represents the entire field of the molecular sciences. I highly recommend that chemistry adopts a healthy self-confidence in the future, in which it does not abandon its classical areas, but resets its boundaries and welcomes interdisciplinary exchanges at all levels. In former times the natural scientist was a all-rounder, knowing nearly everything about chemistry, physics, biology, and medicine. Today this is impossible, and even a all-rounder in chemistry will hardly survive in the future.

To be engaged in research and development is not the only business of a chemist. Many chemists follow a career path in which they seek to climb the job ladder within the management of a company. In the past that could only be realized through learning-by-doing, through enrolling in continuing education courses, or through additional MBA studies. Now, from the outset of their employment, chemists can signalize to their particular company that they wish to pursue a career in management simply by the fact that they have studied business chemistry (economics and chemistry). In Germany, several universities and higher education establishments offer this opportunity. Beyond this, the Gesellschaft Deutscher Chemiker (German Chemical Society) offers courses for younger chemists that culminate in the award of a certificate entitled “project manager of business administration in chemistry”. It is important that in the chemical and related industries, the top positions are filled with business-minded chemists, who have expertise in both areas.

At present, as far as I can see, we urgently need chemists with expertise in science management and communication. We need them to foster the interaction and cooperation between chemists, other scientists, and engineers in university research, in industrial research and development, and between this more or less scientific-technical community and the decision makers as well as the general public. To get national or European subsidies for research and development with the aim to advance innovation in molecular sciences in Germany or Europe, academic and industrial researchers and developers are frequently overwhelmed by the necessary bureaucracy. For the organization and handling of research projects of different types, scientists and engineers are required who have a broad knowledge in their fields, for example chemistry, and other organizational, administrative, and communicational skills. They have to effectively communicate their ideas to the general public, as spokesmen for scientific development and progress, so as to allay any unwarranted fears.

Importantly, the chemistry programs at universities need to provide the ideal environment to develop and hone the problem-solving skills in chemistry. That´s what the public is expecting from chemists and why chemists are needed urgently. For these rea-

sons we need to encourage the brightest students to study chemistry.

What else is there to say about the chemist of the future? Even more than today he or she will need to be a global citizen, and this should be developed already during university studies. Today, in the field of higher education, we talk about the European Education Area as created by the Bologna Process, in which the focus is the mobility of students and the comparability of degrees within Europe. These are important ingredients for both industrial and academic careers, and are also of importance to companies that want to expand and develop new markets abroad.

We should also discuss how we will promote a better use of the term "chemistry" in the future. At present, when the term chemistry is applied in newspapers, television, radio and other media, it has negative connotations in most cases. Sadly, even for highly educated people, chemistry is often associated with something to be afraid of, which probably accounts for why scientists – yes, chemists, too – when they have to write proposals for grants that will be reviewed by non-chemists (that means other scientists or politicians, for instance) avoid the term "chemistry" wherever possible. Even the chemical industry has developed a tendency to avoid the word chemistry (although fortunately not all of them, "BASF – The Chemical Company" being the most prominent counter example) preferring rather to be considered as the life science industry.

Chemistry as a subject at school, in contrast, is not under threat today. Far from it! The question remains, however, why chemistry is offered so late in German schools, and why pupils or students then normally have to learn complicated chemical equations with a complicated stoichiometry at the beginning of their chemistry education? If we could succeed in introducing children at a much younger age more passionately to chemistry, if teachers would start with the achievements chemistry has made possible, if they could discuss new materials and their applications, if they would show chemistry in everyday use and life, before they start with complicated stoichiometries that discourage almost everybody – would that not be a better way to make chemistry more appealing?

Allow me to close on a personal note. In Germany there is consensus that we need better education in science and technology, because we can only improve our world if we understand scientific and technological relationships. We must attract children to the world of science and technology. This can be done in part through campaigns like the Year of Chemistry (which we had in Germany in 2003 and which is planned to be international for 2011), open days in the chemical industry or academic research laboratories, or chemistry shows. All this is nice, but more importantly we need a continuous, exciting, and fascinating education of the sciences from kindergarten nurseries up to high school. Glimmers of hope come in the form of television programs that describe scientific and technical phenomena in an entertaining manner. Depending on the level and depth of explanations, the various programs are targeted at audiences ranging from primary school children to adults. In addition, for those interested, there must be challenges to further improve their scientific training. I therefore consider contests like "Jugend forscht" (Young People's Research) in Germany or the International Chemistry Olympiad as very important tools in this regard.

To sum up, we should earnestly continue the discussions regarding what knowledge and content should form the integral part of the chemistry education from elementary school to Master degrees at universities and what content we should place less emphasis on or simply set aside. It is impossible to produce something like supermen in chemistry – the superchemists. Since the time of Georg Christoph Lichtenberg we know "Who only knows all about chemistry, cannot understand chemistry correctly." But on the other hand: Isn't it better to be an expert idiot than a real idiot?

