Chemistry and Freedom – a Historical Approach

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Science in danger – shifting the feeding bowl for scientists. With this spectacular headline in October 2012 the internet magazine SPIEGEL ONLINE pinpointed the increasing importance of utilitarianism in research. What is it good for? According to Professor Gerd FOLKERS (*1953, professor for Pharmaceutical Chemistry) this ubiquitous question is limiting the freedom of the scientists to follow their own ideas. At a first glance a discussion on the interrelation between chemistry and freedom seems to be rather artificial. But at a second glance it might be worthwhile to reflect on. Might be that a short look into history is appropriate.

Chemistry is a rather young science. The origin is lying in the fog of history. First contours of alchemy in the antique western world are visible at the beginning of our era at the Museion, the famous center of science in Greek-Egypt Alexandria. Alchemy developed during the centuries into a hybrid consisting of mystic-mythic visions interspersed with empirical scientific knowledge. For understandable reasons this pseudo science alchemy temporarily had a bad reputation, which resulted in numerous bans during the centuries. Alchemy and later on chemistry was not independent of external influences, as are religious, ethical or political structures. Since the very beginning, alchemy was strongly affected by religion in the Christian world as well as in the Islamic sphere. The old antique conception of atoms is a typical example. Due to the unbelievably bad image of the Greek philosopher EPICURUS ($\approx$ 341 – 271 B.C.E.) in the Christian church the concept of atoms was vigorously refused until the priest and scientist Pierre GASSENDI (1592 – 1655) succeeded in achieving compatibility with Christian doctrines. It was only since the Renaissance that revolutionary masterminds like Robert BOYLE (1627 – 1691, who questioned the principles of alchemy) and Georg Ernst STAHL (1659 – 1734, who developed the phlogiston theory) prepared the long way to modern scientific chemistry and enabled Antoine Laurent de LAVOISIER (1743 – 1794, oxidation theory) and John DALTON (1766 – 1844, atomic theory) to become founders of modern chemistry. But still in the 20th century non-scientific doctrines were restricting research. In the Third Reich quantum chemistry was regarded to be Jewish and in the Soviet Union Darwin's theory was banned because of non-compatibility with communism. Even nowadays are there noticeable influences, just to mention the stem cell discussion in Germany or the influence of creationism in the U.S.

Obviously external influences are affecting the limits of free research but this is true for intrinsic constraints too. At a certain state of consolidation after controversial discussions the scientific community is agreeing on a common view on the interpretation of phenomena observed in the nature: Then a theory is generally accepted and defined as the valid state of science. According to Thomas Samuel KUHN (1922 – 1996, physicist, philosopher of science) this is a paradigm. A paradigm has a considerable inertia towards change. This behavioral pattern is making sense because it is representing something like a first hygienic filter. New ideas coming up which are not in accordance with the paradigm will be questioned, typically refused at first and combated pertinaciously until a new paradigm replaces the old one. Thinking outside the box is always a challenge and a risk for the established scientific community. Papers in scientific journals are accepted more readily when the editor and the evaluating committees are convinced that the contribution is representing the valid state of science. The scientific circumference has a strong impact on the acceptance of the challengers of existing paradigms. In the history of chemistry innumerable papers have been refused or have simply been neglected after fortunate publication. In case the scientist is not member of an established and recognized group problems increase, even more so when his scientific background is not adequate. 1875 van't HOFF (1852 – 1911, first Nobel price 1901) published his revolutionary ideas on stereochemistry as an unknown professor of a veterinary medical school in Utrecht. He was strongly attacked by the influential and famous chemist August Wilhelm KOLBE (1818 – 1884), and considered to be brazen simply by attempting to solve one of the major problems of chemistry. Van't HOFF was lucky to find a mentor in the chemical establishment. But for most of these unfortunate authors, personal freedom of science is restricted, and career and financial resources are negatively affected. Chemical history knows numerous chemists of this kind. The unlucky ones disappear from scientific life; some of them reappear as a footnote in books on the history of chemistry when a luckier one finally proves to be strong enough to overcome the paradigm. Selected examples are Samuel Shrowder PICKLES (1878 – 1962, who correctly recognized the structure of natural rubber) or Alexandre-Emile Béguyer de CHANCOURTOIS (1820 – 1886, who proposed a precursor of the periodic system of elements). But there were also strong characters like the Nobel award winners Henricus Jacobus van't HOFF (1852

– 1911, stereochemistry), Alfred WERNER (1866 – 1919, complex chemistry) and Hermann STAUDINGER (1881 – 1965, polymer chemistry) who successfully fought old paradigms and finally won their battle.

For research a very simple tool is required: money. Money sometimes seems to be a synonym for freedom. In the very first days of scientific chemistry some nobles such as Robert BOYLE, Henry CAVENDISH (1731 – 1810, discovered hydrogen), and Antoine Laurent de LAVOISIER were extremely successful. They had a decisive advantage compared to others: they were extremely rich. It was not until after the start of the 19th century that chemistry was established at universities as an independent branch of natural sciences, and only since then financial resources have become available for less privileged people. Scientific talents at a broader scale now also had the chance to receive an adequate education.

After the synthesis of Alizarin in 1868, the chemical industry started to recognize the economic value of research. In Germany a dual structure of academic and industrial chemical research interacted and collaborated intensely. A chemist who accepted the benefits of industrial wages consequently had to pay the price in form of a restricted area of applied research and consequently enjoyed less academic freedom. Even now research at university is not totally independent of financial influence as there is frequently external influence due to common projects. Universities are advised to acquire third party funds. They are gaining the financial resources for research; however they have to consider the interests of the partner. This is valid for both public funding and basic research. As Prof. Gerd FOLKERS argued there is a general interest to invest in research projects with a visible return on invest. And additionally it is not at all arbitrary for which projects you are looking for money. The experience teaches that projects are granted much simpler when the topic is in concordance with a scientific mainstream or with a current scientific fashion trend.

But with respect to one important aspect, freedom has been achieved. At the time being everyone who is fulfilling the preconditions for the study of chemistry has the chance to become chemist. Today there are rather equal numbers of male and female students. Reviewing the tables of Nobel Prize laureates you will find astonishing figures. Through today there are more than 150 male laureates but only 4 female: Marie CURIE (1867 – 1934, Nobel prize 1911 for the discovery of the elements Radium and Polonium), Irène JOLIOT-CURIE (1897 – 1956, Nobel prize 1935 for the discovery of the artificial radioactivity), Dorothy CROWFOOD HODGKIN (1910 - 1994, Nobel prize 1964 for the structure determination of vitamin B12) and Ada YONATH (*1939, Nobel prize 2009 for her studies of the ribosome). The history of the role of women in natural science is frustrating and disappointing. The famous revolutionary German reform of universities in 1810 by Wilhelm HUMBOLDT (1767 – 1835, philosopher and government official) was a catastrophe for the education of women because the reform defined the preconditions for academic studies: the examination Abitur was introduced as a qualification precondition for the universities. But the school system in Germany did not provide the Abitur for women and it became available only at the end of the 19th century. German women were systematically excluded from universities for nearly 100 years. Nevertheless, for those who were able to cope with these preconditions similar to the Abitur outside of Germany, the doctorate in Germany was possible. Outside of Germany, the situation was slightly more liberal. Through this method, in Julija Wsewolodowna LERMONTOWA (1847 – 1919) in Göttingen became the first woman with a chemical doctor degree in 1874. In 1900 the first German woman with a doctor degree in chemistry was Clara IMMERWAHR (1870 – 1915), who obtained access to the doctor examination via a complicated method. She became teacher, which was possible for women at this time. By means of this qualification she was accepted only as a visitor at University of Breslau. With that status, she passed successfully the Verbandsexamen (comparable to the diploma in chemistry). Clara IMMERWAHR was a tragic personality. She married Fritz HABER (1868 – 1934, Nobel price for Chemistry 1919). She became very depressed by her husband's activities in World War I, as well as her own disappointing scientific career. She ultimately committed suicide.

In the first half of the last century, the number of female students in chemistry still remained small. When the author studied at the end of the 1960s, just 3% of the students were female during his first semester at his university. These few brave women in the first lecture were not addressed warmly and were told "You should consider that you are blocking rare laboratory capacities for male students". The total average number of female students attending German universities at that time approximately was around 10%. Beginning in the mid 1970s university attendance by females started increasing, with approximately 30% in attendance today. In this regard gender discrimination does not exist any more at German universities.

For natural scientists, freedom is usually associated with Gibb's phase rule and the degrees of freedom. There are obviously other aspects as well.

—Dr. Klaus-Dieter Röker

More information about this subject can be found at:

[1] http://www.spiegel.de/wissenschaft/medizin/forschung-warum-der-utilitarismus-die-freiheit-der-forschung-bedroht-a-860141.html (last access 25.02.2013, 16:00h)

[2] William H. Brock, Viewegs Geschichte der Chemie, Friedrich Vieweg & Sohn, Braunschweig/Wiesbaden **1977**, ISBN 3-528-06645-8