ERNST OTTO FISCHER (1918–2007), ORGANOMETALLIC PIONEER EXTRAORDINAIRE

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Ernst Otto ("E.O.") Fischer (1918-2007), who received the 1973 Nobel Prize in Chemistry for his work on sandwich compounds, died on July 23, 2007 at the age of 88 in Munich [1-4]. The oldest living German chemistry laureate at the time [5], he was buried in the Old Cemetery in Munich-Solln on July 26, 2007 [1].

Ernst Otto Fischer was born in Solln, a southern district of Munich, on Sunday, November 10, 1918, a birthday date that he shared with Martin Luther, the day on which Kaiser Wilhelm II fled to the Netherlands, and one day before the armistice of World War I [6, 7]. He was the third child of Karl Tobias Fischer (1871-1953), Professor of Physics at the Technische Hochschule München (Technical College of Munich) and later Director of the Bavarian Office for Weights and Measures, and his wife, Valentine Fischer (née Danzer), who died in 1935. After four years at a humanistic elementary school Ernst attended the Theresien Gymnasium (high school) in Munich, and in 1937 he received his *Abitur*, the diploma required for higher studies. He was immediately inducted into the *Arbeitsdienst*, a work service, where he spent several months preceding two years of compulsory military service until the outbreak of the Second World War on September 3, 1939.

From 1939 to 1944 Fischer served as a German officer in France, Poland, and Russia. During a short study leave during the winter semester 1941/1942 he attended chemistry lectures at the Technische Hochschule München. He was so fascinated by the teaching on inorganic chemistry by Walter Hieber (1895-1976), the "father of metal carbonyl chemistry," that he decided to turn to chemistry rather than to the history of art, the topic that he had chosen at the end of his Gymnasium studies. Fischer's active service ended after he was wounded in Russia. In 1945 he was captured by the U.S. Army, held in a prisoner of war camp, and released in autumn of the same year.

According to his former student, collaborator, and successor, Wolfgang A. Herrmann, Fischer "belonged to the generation robbed of its youth by the Nazi regime. His bitter experiences on the Russian front in the Second World

War had a powerful influence on the liberal and cosmopolitan sentiments of a scientist who dedicated his career to fundamental research" [1].

Fischer resumed his study of chemistry after the Technische Hochschule reopened in 1946, but first he and his fellow students had to use their bare hands to make the bombed–out institute on the Arcisstraße reusable. He graduated in 1949 *mit Auszeichnung* (with distinction) and was appointed scientific assistant to Professor Hieber in the Inorganic Chemistry Department. The collaboration with Hieber, well known for his early work on compounds of metals with molecules of carbon monoxide, *i.e.,* metal carbonyl chemistry (for example, tetracarbonylnickel(0)), was a premonitory event in Fischer's scientific career: organometallic chemistry would be the *Leitmotiv* of a prodigious nearly six-decade career crowned by the supreme honor of the Nobel Prize.

In 1952 Fischer submitted his Ph.D. thesis titled "The Mechanisms of Carbon Monoxide Reactions of Nickel II Salts in the Presence of Dithionites and Sulfoxylates," which reported a simple synthesis for the versatile reagent tetracarbonylnickel(0), $Ni(CO)_4$ [8]. His *Habilitationsschrift* (original research paper required to teach at a college or university), "The Metal Complexes of Cyclopentadienes and Indenes" [9], followed in 1954, whereupon he was appointed *Privatdozent* (an unsalaried lecturer whose income was derived from *Kollegiengelder* – fees paid by the students who enroll in his courses) at the Technische Hochschule. In 1957 he became a Lecturer at the Ludwig-Maximilians-Universität München, where he was appointed Professor in 1959 after having refused the Chair of Inorganic Chemistry at the Friedrich-Schiller-Universität in Jena. The following year he declined again a call (*Ruf*) as Professor in the Department of Inorganic Chemistry at the Universität Marburg. Eventually, in 1964 he returned for the final time to the Technische Hochschule, assuming the vacant Inorganic Chemistry Chair of his former mentor Walter Hieber. In 1970 the Technische Hochschule became the Technische Universität München (TUM) [10]. Fischer retained this position until his retirement in 1984. He was the fifth successor in the chair created in 1868 for Emil Erlenmeyer (1825-1909). In 1985 Wolfgang A.Herrmann (b. 1948), become Titular Professor in the Chair of Inorganic Chemistry [11].

In 1951 graduate student Thomas J.Kealy and Assistant Professor Peter L.Pauson at Duquesne University in Pittsburgh, Pennsylvania attempted to link two cyclopentadiene (C_5H_5) rings and serendipitously discovered an unknown compound, which they believed involved an iron atom joined to a carbon atom on each ring [12]. Fischer's father drew his son's attention to this article [1]. This compound, initially called dicyclopentadienyl iron, exhibited a high thermal and chemical stability that Fischer considered to be inconsistent with the proposed structure. He thought that it was a new type of molecular

complex. In 1952 the British chemist Geoffrey Wilkinson (1921-1996; future (1973) Nobel chemistry laureate) [13, 14], together with Myron ("Mike") Rosenblum, Mark C.Whiting, and Robert Burns Woodward (1917-1979; future (1965) Nobel chemistry laureate), working at Harvard University, proposed a novel structure in which the iron atom was "sandwiched" between two parallel cyclopentadiene rings and thus formed bonds with the electrons in the rings rather than with the individual carbon atoms, thus accounting for its stability [15, 16]. This was the prototype of a "sandwich" compound, renamed ferrocene, a term introduced by Whiting to emphasize its similarity to benzene.

Geoffrey Wilkinson

Meanwhile, Fischer and Wolfgang Pfab confirmed the structure of ferrocene, which was especially stable because its electronic structure was similar to that of a noble gas, by careful x-ray analysis [17]. Fischer and Wilkinson were both credited for this extraordinary discovery, which more than half a century ago opened a new, immense field in chemistry bridging the worlds of organic and inorganic chemistry, to which Fischer contributed overall about 450 articles.

Fischer followed the synthesis of ferrocene with those of similar cyclopentadienyl sandwich compounds with cobalt (cobaltocene), nickel (nickelocene), and other main group metals [18]. Fischer then had another idea, a most daring one at the time – the synthesis of similar compounds with two *neutral* molecules bonded to a *neutral* zerovalent metal atom. In 1955 this led him and his gifted student Walter Hafner to the discovery of dibenzenechromium or bis(benzene)chromium(0), the first example of a π-bonded metal with benzene [19, 20], which was followed by more than 200 publications on aromatic metallic complexes [21]. Fischer pursued these researches primarily for their own theoretical interest, but they also led to significant applications, for example, catalysis on both laboratory and industrial scales (Ziegler mixed organometallic catalysts and catalysts for olefin metathesis).

In 1964, together with his student Alfred Maasböl, Fischer made a tremendous step forward with the synthesis of the first "Fischer *carbene*" complex, containing a double bond between the metal (tungsten) and carbon atoms, a success considered to be Fischer's second masterpiece (after ferrocene) [22]. This was followed in 1973 with his third masterpiece, coauthored with student Gerhard Kreis, of the synthesis of the first *carbyne* complex with a triple bond linking tungsten and carbon [23, 24].

Over more than three decades Fischer and his collaborators – more than 200 diploma and doctorate students as well as postdoctoral fellows from all

over the world – prepared and characterized hundreds of new substances at the Technische Universität München. More than a dozen of Fischer's former students were called to occupy prestigious university chairs.

Fischer founded and edited until 1993 the weekly *Journal of Organometallic Chemistry*, the most cited periodical in the field. He also published numerous reviews in another Elsevier journal, *Advances in Organometallic Chemistry*. After the discovery of ferrocene Fischer's researchers in Munich and Wilkinson's researchers in London [25] realized immediately that a harsh competition, characterized by Herrmann as "strong and not always harmonious" [1], would follow. Both teams worked independently, and their only joint event was the award of the 1973 Nobel Prize in Chemistry, shared between the two group leaders of nearly the same age (55 and 52 years, respectively), "half each to Professor Ernst Otto Fischer, Munich and Professor Geoffrey Wilkinson, London, for their pioneering work, performed independently, on the chemistry of the organometallic so called sandwich compounds" [26].

On December 10**,** 1973 in his presentation speech to the two Laureates, Ingvar Lindqvist, a member of the Nobel Committee for Chemistry of Svenska Kungliga Vetenskapsakademien (the Swedish Royal Academy of Sciences) recalled that 1965 Nobel chemistry laureate Robert Burns Woodward had "reached the conclusion that certain compounds could not be understood without the introduction of a new concept, namely that of the sandwich compound… Now the science of chemistry involves, of course, more than flashes of visionary inspiration, and both Fischer and Wilkinson did not hesitate to confirm and develop the concept of the sandwich compounds by an intensive experimental effort… Amongst other things, Fischer managed to surprise chemists by preparing a sandwich of chromium between two benzene molecules. The culinary exploits were pursued further with the progress to open sandwiches, having a flat molecule on one side of the metal atom, and with only small molecules such as carbonyl, methyl or ethyl groups on the other side" [26].

Lindqvist addressed Fischer in German: "Die Entdeckungen vollständig neuer Prinzipien der chemischen Bindung und Struktur sind immer grosse Augenblicke in der Geschichte der Chemie gewesen. Sie haben zu einer solchen Entdeckung in hervorragender Weise beigetragen" (The discoveries and confirmation of completely new types of chemical bonding and structure have always been considered great moments in the history of chemistry. You have contributed to such a discovery in a decisive way) [26].

Nobel chemistry prizes were awarded previously to chemists for researches dealing with organometallic compounds: in 1912 to the Frenchman Victor Grignard (1871-1935) for organomagnesium compounds ("Grignard reagents"); in 1963 to the German Karl Ziegler (1898-1973) and the Italian Giulio Natta (1903-1979) for organoaluminium compounds; and in 1964 to the

Briton Dorothy Crowfoot Hodgkin (1910-1994) for the carbon-cobalt bond in vitamin B_{12}. Fischer's didactic Nobel lecture, "On the Road to Carbene and Carbyne Complexes" [27], presented on December 11, 1973, cited 110 references, 70 of which were to his own work. On the same day Wilkinson devoted his Nobel lecture to "The Long Search for Stable Transition Metal Alkyls " [28]. The two laureates had different characters. Wilkinson was more intellectual; his monumental treatise, *Advanced Inorganic Chemistry*, co-authored primarily with F.Albert Cotton, is a standard by which all other chemistry books are judged [29], while Fischer was more coherent and diligent, preferring to write research reviews rather than textbooks. Furthermore, from the early stages of his work Wilkinson was interested in the catalytic effects of organometallic compounds, such as the use of rhodium complexes, for example, "Wilkinson's catalyst" (chlorotris(triphenylphosphene)rhodium(I),RhCl $\{P(C_6H_5)_3\}_3$) to bring about hydrogenation and oxosynthesis reactions [13, 14], whereas Fischer focused exclusively on the structures and reactivities of these compounds [1].

The Fischer carbenes were important in the development of olefin methathesis. In 1971 Yves Chauvin (b. 1930), a chemist at the Institut Français du Pétrole (French Petroleum Institute), suggested that olefin methathesis could be initiated by a metal carbene. Several years were required to elucidate the mechanism, a success that earned him the 2005 Nobel chemistry prize [30]. Chauvin acknowledged that he was led to his hypothesis from the 1964 paper by Fischer and Alfred Maasböl on tungsten carbene [22].

In 1957 Fischer received the Chemistry Prize of the Akademie der Wissenschaften zu Göttingen, the second oldest of the seven German science academies, and in 1959 the Alfred-Stock Prize of the Gesellschaft Deutscher Chemiker [31]. He was elected to the Mathematics/Natural Science Section of the Bayerische Akademie der Wissenschaften (Bavarian Academy of Sciences and Humanities) in 1964 and to the Deutsche Academie der Naturforscher Leopoldina in 1969 [32]. Fischer also received *Verdienstorden* (rewards for merit) from the German Federal Republic and Bavaria (1974). He was awarded honorary doctorates from the Faculty of Chemistry and Pharmacy of the Universität München (1975), the University of Strathclyde in Glasgow (1975), the Friedrich-Alexander-Universität Erlangen in Nuremberg (1977), and the University Pannnonia (until 2006 Veszprém University) in Hungary (1983).

Fischer was a Member of the Austrian Academy of Sciences and the Italian Accademia dei Lincei as well as a Corresponding Member of the Göttingen Academy of Sciences (1977) and the Rheinisch-Westfällische Academy of Sciences (1987). He was an American Chemical Society Centennial Foreign Fellow (1976), an Honorary Member of the American Academy of Arts and Sciences (1977), an Honorary Fellow of the Chemical

Society (London) (1979), and he received the Bavarian Maximilian Order for Science and Art (1981). Fischer was the Firestone Lecturer at the University of Wisconsin, Madison (1969), a Visiting Professor at the University of Florida, Gainesville (GBK's *alma mater*) (1971), and the first Inorganic Chemistry Pacific West Coast Lecturer. In the spring of 1973 he was the Arthur D.Little Visiting Professor at the Massachusetts Institute of Technology in Cambridge and was a Visiting Distinguished Lecturer at the University of Rochester in New York. He lectured on his research in most European countries as well as in Australia, Venezuela, Brazil, Israel, and Lebanon.

"Mediator between Chemical Worlds, Æsthete of Sciences, and Man of Bavaria" [33]

On the occasion of the fiftieth anniversary of the discovery of ferrocene, F.Albert Cotton (1930-2007) [34] considered Fischer's pioneering work on sandwich compounds as a perfect example of a change of paradigm proposed by historian of science Thomas S.Kuhn (1922-1996) in his seminal book, *The Structure of Scientific Revolutions* [35]. Fischer's work as well as that of Wilkinson fundamentally changed the perspectives and objectives of the entire field of organometallic chemistry, bridging the classical academic distinctions between organic and inorganic chemistry. It confirmed the fact that science progresses the most at the edges of *a priori* unconnected fields.

After retiring from the Chair of Inorganic Chemistry, Fischer pursued his scientific activities for more than an additional two decades. The Technische Universität München paid tribute to him on the occasions of his 70th [36], 75th [37], and 85th anniversaries [38]. He was "an intense personality; impulsive and thoughtful, urbane and homely, rowdy and modest, scientist and esthete. These apparent contradictions made complete a person with equal measure of heart and reason" [2].

Chemistry was Fischer's life, and he considered his students and collaborators as his family, with whom he shared successes and failures. Fundamental research was his unique passion, and he paid no attention to the practical applications of his prodigious results. He was driven by curiosity and wonder, and he communicated his enthusiasm to his young collaborators. As a Spartan, *i.e.,* a self-disciplined, rigorously simple, frugal person, he thought that they should neither smoke nor get married. Fischer remained a confirmed bachelor until his retirement, after which he shared his life with Traudl Haas.

As a humanist, Fischer considered chemistry as a part of culture, like art and literature. Occasionally, he intervened in politics. Despite his liberal inclinations, he found the 1968 student revolt excessive. On one occasion he entered the lecture hall with a copy of Adolf Hitler's *Mein Kampf* in one hand and Chairman Mao's *Red Book* in the other, urging students to avoid any political extremism. Fischer was a Bavarian chauvinist in the best sense of the word. He spent all his life in Munich, where he practiced the Benedictine vow

of stability, “stabilitas loci,” declining proposals of positions from prestigious universities. In return the City of Munich awarded this famous citizen the Golden Medal "München leuchtet," the official honor established in 1961 for special service to Munich.

Acknowledgment. We are pleased to acknowledge the assistance of Diane Majors of the Henry Madden Library, California State University, Fresno for locating numerous valuable reference sources.

References and Notes[1]

1. Herrmann, W.A. Obituary: Ernst Otto Fischer (1918-2007). Organic chemist, and cosmopolitan Bavarian patriot. *Nature* **2007**, *449*, 156.

2. Herrmann, W.A. Obituary: Ernst Otto Fischer. *Angew. Chem., Internat. Ed.* **2007**, *46*, 6578.

3. GDCh-Ehrenmitglied und Nobelpreisträger E.O.Fischer am 23.Juli verstorben. *Nachrichten aus der Chemie* **July 26, 2007**, *Heft 9*, 887.

4. Nobelpreisträger Ernst Otto Fischer gestorben. http://science.orf.at/science/news/148849 (accessed Oct 2007).

5. After Fischer's death the oldest German Nobel laureate is Manfred Eigen (b. 1927), who shared the 1967 chemistry prize with Ronald George Wreyford (R.G.W.) Norrish (1897-1978) and Sir George Porter (1920–2002).

6. Bonnesen, P.V. Ernst Otto Fischer 1918-. In *Nobel Laureates in Chemistry, 1901–1992*; James, L.K., Ed.; American Chemical Society: Washington, DC, 1993; pp 551-556.

7. Ernst Otto Fischer: Translation from the German Text. In Nobel Foundation. *Nobel Lectures Including Presentation Speeches and Laureates' Biographie: Chemistry 1971-1981*; World Scientific Publishing Co.: Singapore; River Edge, NJ, 1993; pp 103-104; http://nobelprize.org/nobel_prizes/chemistry/laureates/1973/fischer-autobio.html (accessed Oct 2007).

8. Hieber, W.; Fischer, E.O. Über den Mechanismus der Kohlenoxydreaktion von Nickel(II)- und Kobalt(II)-Salzen bei Gegenwart von Dithionit. *Z. Anorg. Allg. Chem.* **1952**, *269*, 292-307.

9. Fischer, E. O. Metallverbindungen des Cyclopentadiens und des Indens. *Angew. Chem.* **1955**, *67*, 211-215.

10. Three Nobel laureates studied, earned their doctorates, and held chairs at the Technische Universität München: Rudolf Ludwig Mößbauer (b.1929; Physics 1961), Robert Huber (b.1937; Chemistry 1988) and E.O.Fischer.

11. Wolfgang Anton Herrmann was elected President of the Technische Universität München in 1995 and reelected for the third time in 2007. His scientific interests cover the entire field of organometallic chemistry. He was the most cited German chemist during the period 1995-2005 and held the 24th rank among the 100 most cited scientists in chemistry.

12. Kealy, T.J.; Pauson, P.L. A new type of organo-iron compound. *Nature* **1951**, *168*, 1039-1040. This paper appeared on December 15, 1951. One month later a synthesis of the same compound was reported independently by a group at the British Oxygen Company, Ltd.: Miller, S.A.; Tebboth, J.F.; Tremaine, J. Di*cyclo*pentadienyl iron. *J. Chem. Soc*. **1952**, 632-635. The chronology of these

[1] Библиографические описания сохранены в авторской редакции. – *Прим. ред.*

two articles has been analyzed by Kauffman, G. B. The Discovery of Ferrocene, the First Sandwich Compound. *J. Chem. Educ*. **1983**, *60*, 185-186. See also Laszlo, P.; Hoffmann, R. Ferrocene: Ironclad history or Rashomon tale? *Angew. Chem., Int. Ed*. **2000**, *39*, 123-124; Pauson, P.L. Ferrocene – How It All Began. *J. Organometallic Chem.* **2001**, *637*, 3-6; and Dagani, R. 50 Years of Ferrocene Chemistry. *Chem. Eng. News* **December 3, 2001**, *79* (49), 37–38. According to F. Albert Cotton, the discovery of ferrocene should be credited to S.A.Miller *et al.* (Cotton, F.A. Au temps de l'établissement de la structure du ferrocène. Témoignage sur cette aventure. *L'Actualité Chimique* **2002**, *July,* 28–29).

13. Kauffman, G. B. Sir Geoffrey Wilkinson. In *Biographical Encyclopedia of Scientists ;* Olson, R.; Smith, R., Eds.; Marshall Cavendish Corporation: New York, NY, 1998; Vol. 5, pp 1356–1358.

14. Kauffman, G.B. Sandwich Compounds of Transition Metals: A Retrospective View of Sir Geoffrey Wilkinson (1921-1996) on the 10th Anniversary of His Death. *Chem. Educator* **2006**, *11*, 334-344 ; DOI 10.1333/s00897061067a.

15. Wilkinson G.; Rosenblum, M.; Whiting, M.C.; Woodward, R.B. The structure of iron bis-cyclopentadienyl. *J. Am. Chem. Soc*. **1952**, *74*, 2125-2126.

16. Wilkinson, G. The iron sandwich. A recollection of the first four months. *J. Organometallic Chem*. **1975**, *100*, 273-278.

17. Fischer, E.O.; Pfab, W. Zur Kristallstruktur der Di-Cyclopentadienyl-Verbindungen des zweiwertigen Eisens, Kobalts und Nickels. *Z. Naturforsch.* **1952**, *B7*, 377-379.

18. Fischer, E.O. Über Cyclopentadien-Komplexe des Eisens und des Kobalts *Angew. Chem*. **1952**, *67*, 620-623.

19. Seyferth, D. Bis(benzene)chromium. 2. Its discovery by E.O.Fischer and W.Hafner and subsequent work by the Research Group of E.O.Fischer, H.H.Zeiss, F.Hein, C. Elschenbroich and others. *Organometallics* **2002**, *21*, 2800-2820.

20. Fischer, E.O.; Seus, D. Zur Frage der Struktur der Chrom-phenyl – Verbindungen. *Chem. Ber.* **1956**, *89*, 1809-1815.

21. Fischer, E.O.; Fritz, H.P. Π complex benzenoid systems with transition metals. *Angew. Chem.* **1961**, *73*, 353-364 (includes 163 references).

22. Fischer, E.O.; Maasböl, A. On the existence of a tungsten carbonyl carbene complex. *Angew. Chem., Internat. Ed.* **1964**, *3,* 580-581.

23. Fischer, E.O. On the way to carbene and carbyne complexes. *Adv. Organometallic Chem.* **1976**, *14*, 1-32.

24. Fischer, E.O. Preparation, properties, and reactivity of transition metal carbonyl-carbyne complexes. *J. Organometallic Chem*. **1975**, *100*, 59-81.

25. Geoffrey Wilkinson (1921-1996) was recruited in 1952 by Friedrich Adolf Paneth (1887-1958), pioneer in radiochemistry and founder of cosmochemistry, as a young chemist for the nuclear energy project of Canada and worked for four years with Glenn T.Seaborg (1912-1999) at the University of California, Berkeley. From 1951 to 1955 Wilkinson was an Assistant Professor at Harvard where he begun to work on olefin complexes and learned of the discovery of ferrocene. In 1955 he was appointed to the Chair of Inorganic Chemistry at the Imperial College of the University of London, which at the time was the only established chair of inorganic chemistry in the United Kingdom. Wilkinson also prepared the first sandwich compound containing a direct bond between a metal atom, rhenium, and

a hydrogen atom. For additional detailed information about Wilkinson see references 13 and 14.

26. The Nobel Prize in Chemistry 1973. Presentation Speech by Professor Ingvar Lindqvist of the Royal Academy of Sciences. In Nobel Foundation. *Nobel Lectures Including Presentation Speeches and Laureates' Biographies: Chemistry 1971-1981*; World Scientific Publishing Co.: Singapore; River Edge, NJ, 1993; pp 99-10; http://nobelprize.org/nobel_prizes/chemistry/laureates/1973/presentation-speech.html (accessed Oct 2007).

27. Fischer, E.O. On the Road to Carbene and Carbyne Complexes. Nobel Prize lecture, December 11, 1973 (translated from the German). In Nobel Foundation. *Nobel Lectures Including Presentation Speeches and Laureates' Biographies: Chemistry 1971-1981*; World Scientific Publishing Co.: Singapore; River Edge, NJ, 1993; pp 105-132; http://nobelprize.org/nobel_prizes/chemistry/laureates/1902/fischer-lecture.html (accessed Oct 2007); *Angew. Chem*. **1974**, *86*, 651-663 (original German version).

28. Wilkinson, G. The Long Search for Stable Transition Metal Alkyls. Nobel Prize lecture, December 11, 1973. In Nobel Foundation. *Nobel Lectures Including Presentation Speeches and Laureates' Biographies: Chemistry 1971-1981*; World Scientific Publishing Co.: Singapore; River Edge, NJ, 1993; pp 137-145; http://nobelprize.org/nobel_prizes/chemistry/laureates/1973/wilkinson-lecture.pdf (accessed Oct 2007).

29. Cotton, F.A. ; Wilkinson, G. *Advanced Inorganic Chemistry: A Comprehensive Text* ; Interscience Publishers: New York, NY, 1962; 2nd ed.; 1966; 3rd ed.; 1972; 4th ed.; John Wiley & Sons, Inc.: New York, NY, 1980; 5th ed.; 1988; Cotton, F.A. ; Wilkinson, G.; Murillo, C.A.; Bochmann, M. *Advanced Inorganic Chemistry*, 6th ed.; 1999. For book reviews of each edition by George B. Kauffman see *J. Chem. Educ.* **1963,** *40*, 230; *J. Chem. Educ.* **1967,** *44*, A240, A244; *J. Chem. Educ.* **1973,** *50*, A347–A348; *J. Chem. Educ.* **1981,** *58*, A204; *Polyhedron* **1989,** *8,* 705-706; *Chem. Educator* **1999**, *4*, 268-270; DOI 10.1333/s00897990345a.

30. The Americans Robert H.Grubbs (b.1942) of the California Institute of Technology and Richard R.Schrock (b.1945) of the Massachusetts Institute of Technology were co-recipients with Chauvin of the 2005 Nobel Chemistry Prize "for the development of the metathesis method in organic synthesis;" http://nobelprize.org/nobel_prizes/chemistry/laureates/2005 (accessed Oct 2007). According to Wolfgang A.Herrmann, without Fischer's original research, their olefin metathesis would not have been possible [1].

31. The German inorganic chemist Alfred Stock (1876-1946), Director of the Technische Hochschule Karlsruhe is renowned for his pioneering research on boron hydrides. The term "ligand" was first used by Stock in 1916 in relation to silicon chemistry (Brock, W.H.; Jensen, K.A.; Jørgensen, C K.; Kauffman, G.B. The Origin and Dissemination of the Term "Ligand" in Chemistry. *Polyhedron* **1983***, 2*(1), 1-7; summarized in The Name Game. *Chemistry Education* April-June, **1985**, *1*(4), 7-8).

32. The Leopoldina, founded in 1652 in Schweinfurth, is the oldest academy in Germany; since 1878 its seat has been in Halle. Members selected from all over the world have distinguished themselves by demonstrating scientific excellence. The number of members is limited to one thousand.

33. Herrmann, W.A. Mediator between chemical worlds, æsthete of sciences, and man of Bavaria: Ernst Otto Fischer. *J. Organometallic Chem.* **2003**, *684* (1-2), 1-5.

34. Cotton, F.A. Reference 12, *op. cit.*

35. Kuhn, T.S. *The Structure of Scientific Revolutions*; University of Chicago Press: Chicago, IL, 1962.
36. Herrmann, W.A. Abenteuer Forschung. Ernst Otto Fischer zum 70. Geburtstag. *TUM-Mitteilungen* **1988/89,** *1*, 27-32.
37. Sonderheft zum 75. Geburtstag von Ernst Otto Fischer. *Z. Naturforsch. B*, **1993**, *48*, 1438-1692.
38. Herrmann, W.A. Ernst Otto Fischer 85 Jahre. *TUM-Mitteilungen* **2003/2004,** *2*, 43-44.