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REVIEW ARTICLE

Immortal fame of the Swedish apothecary and chemist: Carl Wilhelm Scheele (1742-1786) in the literature between the 19th and 21th centuries

Fama inmortal del boticario y químico sueco Carl Wilhelm Scheele (1742-1786) en los siglos XIX y XXI

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ABSTRACT

In this article the literature on Carl Wilhelm Scheele (1742-1786) is reviewed, including books on chemistry and the history of chemistry, published between the 18th and the 21st century in different countries in order to: 1) familiarize readers with the names of authors of biographies and biographical notes about Carl Wilhelm Scheele, published in books in 1833-2017, 2) discusse the priority problem for the discovery of oxygen by Joseph Priestley (1733-1804) and Scheele, 3) familiarize readers with literature sources regarding Scheele's letter to Antoine Laurent Lavoisier (1743-1794), written on September 30, 1774, 4) show the causes of Scheele's premature death, 5) familiarize readers with opinions about Scheele expressed by chemists in 1819-1942. To convey the atmosphere in which the authors of books in various countries created them, as well as to express their feelings about Scheele, and in order to avoid unintentional transformations of their thoughts, in this article, authors words are quoted in literal wording. Their reading may be helpful in the education of the students of chemistry, because looking at certain issues through the prism of the history of science will certainly facilitate the acquisition and understanding the knowledge by them. This article will be a source of reflection regarding the history of chemistry, in which Scheele, Priestley and Lavoisier were active.

Keywords: C. W. Scheele; J. Priestley; A. L. Lavoisier; Scheele's letter; discovery of oxygen; toxic substances

RESUMEN

El artículo revisa la literatura sobre Carl Wilhelm Scheele (1742-1786), incluyendo libros de química y la historia de la química, publicado entre el siglo 18 y el siglo 21 en diferentes países. Ello será con el fin de: 1) familiarizar a los lectores con los nombres de los autores de biografías y notas biográficas sobre Carl Wilhelm Scheele, publicados en libros durante 1833-2017, 2) discutir el problema prioritario para el descubrimiento del oxígeno por Joseph Priestley (1733-1804) y Scheele, 3) familiarizar a los lectores con fuentes de la literatura en relación con la carta de Scheele a Antoine Laurent Lavoisier (1743-1794), escrito el 30 de septiembre, 1774, 4) mostrar las causas de la muerte prematura de Scheele, 5) familiarizar a los lectores con las opiniones sobre Scheele expresadas por los químicos durante 1819-1942. Para transmitir la atmósfera en la que los autores de libros en varios países los creó, así como para expresar sus sentimientos acerca de Scheele, y con el fin de evitar transformaciones no intencionales de sus pensamientos, en este artículo, se citan textualmente a los autores fuente. Este artículo será una fuente de reflexión respecto a la historia de la química, en el cual Scheely, Priestley y Lavoisier fueron activos.

Palabras clave: C. W. Scheele; J. Priestley; A. L. Lavoisier; La carta de Scheele; descubrimiento de oxígeno; sustancias tóxicas

Carl Wilhelm Scheele. Descriptions of his life and activities in books on chemistry and pharmacy

From the third decade of the 19th century to the 21st century, books with Scheele's biographies were published in eight countries. The authors' names of such books and their publication dates are chronologically displayed below:

- In 1833-2017, Scheele's biographies were written by the Swedish authors Johan Fredric Sacklén (1833, pp. 253–260), Per Teodor Cleve (1886), Christian Wilhelm Blomstrand (1891, pp. 1–38), Gunnar Svedberg (2012, pp. 8–43), and Anders Lennartson (2017, pp. 19–103).

- Biography of C. W. Scheele was presented to readers by Jean Baptiste Dumas (1837, pp. 87–100). A Scheele's biographical books wrote also Paul Antoine Cap (1863,) and Ferdinand Hoefer (1869, pp. 450–472) in France.

- In 1904-1959, in Germany, a biographical note about Scheele, along with the details of his discoveries, was written by Hermann Schelenz (1904, pp. 556–558). Hugo Bauer, in his *A History of Chemistry*, devoted only part of the page to the description of Scheele's life (Bauer, 1907, p. 70). A biography of Scheele has also been written by Georg Lockemann (1959, pp. 105–117).

- British chemist Sir William Ramsay, wrote a biographical note about Scheele (Ramsay, 1915, pp. 84–102). Scheele's biographies were written by Sir William Augustus Tilden (1913, p. 82; 1921, p. 53–62). In the third volume of the book written by James Riddick Partington is Scheele's biography (Partington, 1962).

- In USA, Forris Jewett Moore described life and discoveries of Scheele in his book (Moore, 1918, pp. 36–39). Scheele's biographical book also was written by George Urdang (1942). Henry Monmouth Smith wrote a short biographical note about Scheele (Smith, 1949, pp. 225–227). Mary Elvira Weeks, described Scheele's life and work in the sixth edition[1] of the book entitled *Discovery of Elements* (Weeks, 1960, p. 221–226).

- In Austria, Otto Zekert published three biographical books about C. W. Scheele (Zekert, 1931-1934, 1936, 1963). The book, which was published in 1931-1934, had seven parts: Part 1 (1931), Part 2 (1932) and Parts 3-7 (1934) (Zekert, 1931-1934). Scheele's biography published in 1936 was titled *Carl Wilhelm Scheele. Gedenkschrift zum 150. Todestage* (Carl Wilhelm Scheele, Memorial to the 150th Anniversary of Death), while biography in 1963 were published with the title *Carl Wilhelm Scheele: Apotheker, Chemiker, Entdecker* (Carl Wilhelm Scheele: Apothecary, Chemist, Discoverer).

- In 1942, Italian, Michele Giua (1889-1966), wrote a book entitled *La Storia della Chimica* (Giua, 1942). In 1975, this book was published in Moscow in a Russian translation. The author in this book briefly described the life and discoveries made by Scheele (Dzhua, 1975, pp. 120–122).

- In 1979, Nikolay Alexandrovich Figurovsky (1901-1986), in his *Istoriya khimii* (History of Chemistry), briefly described Scheele's life and discoveries (Figurovskiy, 1979, pp.

[1] The first edition of this book was published in 1935.

55–57) in the Soviet Union.

Priestley or Scheele. The priority for the discovery of oxygen in books published in 1892-2009

In 1892, the book entitled *Carl Wilhelm Scheele. Nachgelassene Briefe und Aufzeichnungen* (Carl Wilhelm Scheele. Posthumous Letters and Records) was published by the geologist, mineralogist and traveler Adolf Erik Nordenskiöld (1832-1901)[2], with many of Scheele's letters, and extracts from his laboratory notebooks. Forris Jewett Moore (1867-1926), professor of Organic Chemistry in the Massachusetts Institute of Technology (USA), wrote in his book entitled *A History of Chemistry* about Nordenskiöld's book: "We now know from the notebooks first published long after his [Scheele] death that he prepared the latter element [oxygen] in three or four different ways before the famous experiments of Priestley in 1774" (Moore, 1918, p. 37).

Prior to 1892, the authors of chemical books considered English chemist Joseph Priestley (1733-1804) to be the main discoverer of oxygen. For example, in 1855, Lord Henry Brougham (1778-1868) in his book entitled *Lives of Philosophers of the Time of George III wrote*: "Oxygen gas had been discovered, in August, 1774, by Priestley, and soon after by Scheele without any knowledge of Priestley's previous discovery" (Brougham, 1855, p. 10).

Chemistry historian Ernst von Meyer (1847-1916), professor of chemistry in the Technical High School in Dresden (Germany), in the book entitled *A History of Chemistry from Earliest Times to The Present Day*, which was published in London in 1898, provided readers an information about the discovery of oxygen by Priestley and Scheele as well as about Scheele's laboratory notebooks:

> The journals already alluded to make it clear that as early as 1771-1773, *i.e.* during the years of his sojourn at Upsala [Uppsala], Scheele prepared oxygen by heating black oxide of manganese [manganese dioxide] with sulphuric or arsenic acid, and also from nitrates and from the oxides of mercury and silver [mercury and silver oxides], and noted its characteristics clearly. Priestley, who likewise observed the gas at about the same time, without, however, recognising its peculiar nature, (…) first isolated it for certain on August 1st, 1774, by heating red oxide of mercury [mercury oxide]; and, as he published his results earlier than Scheele, he has hitherto been regarded as the first discoverer of oxygen, whereas we now know the converse to be the case. Both observed that this gas was capable of supporting combustion and respiration in an intensified degree (Meyer, 1898, p. 131).

In 1900, in Edinburgh (Scotland) was published a book written by Albert Landenburg (1842-1911), professor of Chemistry in the University of Breslau, Germany (now, Wrocław, Poland), entitled *Lectures on the History of the Development of Chemistry since the Time of Lavoisier*. Landenburg knew that A. E. Nordenskjöld even endeavours to prove that the priority belongs to Scheele rather than to Priestley, but he did not agree with that. In his book:

> Priestley discovered oxygen in 1771. He isolated and examined it, and the priority of the discovery is his. He published a detailed account of it in 1775. (…) Scheele's investigation appeared two years later[3], but it has been shown that his experiments were

[2] The Arctic Voyages of A.E. Nordenskiöld in 1858-1879 were described by Alex Leslie in 1879. The book also contains Nordenskiöld's autobiographical sketch (Leslie, 1879, pp. 1–39).

[3] In 1777, Scheele published the results of his investigation on air, oxygen and combustion at Uppsala and Leipzig in a book entitled *Chemische Abhandlung von der Luft und dem Feuer* (Chemical Treatise on the Air and the

> independent of and nearly simultaneous with those of Priestley. (…) Both chemists employed almost similar methods for its preparation. They obtained it from mercuric oxide, pyrolusite[4], minium [lead oxide][5], nitre [potassium nitrate][6], etc. (Landenburg, 1900, pp. 16–17).

In the fourth corrected and improved German edition of this book, from 1907, and Russian translation of this book from 1917, information about the discovery of oxygen by Priestley and Scheele was corrected by Landenburg.

> Priestley discovered the oxygen gas on August 1, 1774; he isolated and examined it; but a few months before Scheele had already made the same discovery, so that he deserves the priority (...) However, Priestley's observations have been published before those of Scheele, so that he is usually considered the discoverer of oxygen (Landenburg, 1907, p. 17; 1917, p. 16).

Chemistry historian Karl Hugo Bauer (1874-1944), from Royal Technical Institute in Stuttgart (Germany), was the author of the book published in London in 1907, entitled *A History of Chemistry*. He wrote in this book:

> Complete clearness in this connexion was brought by the discovery of oxygen, which was isolated by Priestley on August 1, 1774, and also independently, by another method, by Scheele about the same time. Priestley prepared it first by heating mercuric oxide, and afterwards also, as a check upon his experiments, by heating red lead. He recognized oxygen as a gas not absorbed by water, and capable of supporting extraordinarily vigorous combustion. Scheele's starting-point for the preparation of oxygen was black oxide of manganese, which he heated with phosphoric or sulphuric acid. He also found that the gas evolved on heating saltpetre is identical with that obtained from manganese dioxide. The further investigations which he carried out with this gas soon led to its recognition as the substance which was the active principle in respiration and combustion. Its discoverers, however, did not agree with this view. We have already seen that both Priestley and Scheele were supporters of Stahl's phlogistic theory till their deaths, and so it is not remarkable that they explained the reactions of this gas also in that way. From Priestley it obtained the name of ' dephlogisticated air,' while Scheele called it 'fire-air' (Bauer, 1907, p. 71–72).

In 1915, Sir William Ramsay (1852-1916) in the third chapter of the book entitled *The Gases of the Atmosphere. The History of Their Discovery*, wrote that Scheele should be given priority for the discovery of oxygen.

Fire) (Scheele, 1777). Chemistry historian Paul Walden (1863-1957), honorary professor of the Tübingen University (Germany), wrote about it in German, but the translation into English is as follows: "(The publication of these studies, which had probably been completed in 1774, was delayed at the time of going to print in Uppsala and Leipzig.) The great LAVOISIER praised SCHEELE "for his extraordinary efforts because of the variety of his interesting experiments and the simplicity of his apparatuses and the accuracy of the results obtained" (Walden, 1952, p. 19–20). Anders Lennardson in his *The Chemical Works of Carl Wilhelm Scheele* described in more detail the delay in the publication of this book. „Scheele did not start to write his oxygen manuscript until 1775, and it was sent to the publisher, Magnus Swederus, in late December 1775 or early January 1776. Unfortunately, Swederus and the printer, Johan Edman, were very slow and the printing ... was not finished until August 1777" (Lennardson, 2017, p. 8).

[4] "Scheele, in 1774, described the properties of the mineral "manganese," now known as pyrolusite or black oxide of manganese, MnO_2" (Lowry, 1915, p. 229).

[5] "red lead" (Lowry, 1915, p. 47).

[6] *Ibid*, p. 47.

> The discovery of oxygen was made nearly simultaneously by Priestley and Scheele, though it appears from the recent publication of Scheele's laboratory notes by Baron Nordenskjöld that Scheele had in reality anticipated Priestley by about two years. His researches, however, were not published until a year after Priestley had given to the world an account of his experiments (Ramsay, 1915, p. 69–70).

In 1920, in London a second edition of the book entitled *A History of Chemistry from the Earliest Times* was published. The author of this book was English chemist James Cambell Brown (1843-1910), professor at the University of Liverpool. He wrote in this book that Scheele discovered oxygen almost at the same time as Priestley. "It must be borne in mind, however, that Scheele independently discovered oxygen about the same date as Priestley, although he did not publish his discovery until three years later" (Brown, 1920, p. 285).

Francis Preston Venable (1856-1934), American chemist, in his book entitled *History of Chemistry*, published in 1922, points to Priestley and Scheele as independent discoverers of oxygen, and Lavoisier as the one who overthrew the theories of phlogiston.

> It was the discovery of oxygen that struck the death blow to the phlogiston theory. Strange to say it was discovered and identified in 1774 by Priestley and independently by Scheele, both of them phlogistics, who failed to grasp its bearing upon the phlogiston theory. In the hands of Lavoisier, the great Frenchman, it revealed the secret of combustion. Priestley visited Paris and showed Lavoisier how to prepare it by first heating mercury in the air until the red precipitate was formed. When this was placed under a bell-jar from which the air had been pumped and was heated, the original mercury was regained with liberation of a gas which would support combustion (Venable, 1922, pp. 36–37).

In the second half of the twentieth century, the priority of C. W. Scheele for the discovery of oxygen is no longer questioned by any historian of chemistry. This is confirmed by information available in books published in many countries, in different languages. For example, in 1983 in the Soviet Union, a book written by chemistry historian Yuriy Ivanovich Soloviev (b.1924)[7], professor of chemical sciences, was published. This book entitled *Istoriya khimii. Razvitiye khimii s drevneyshikh vremen do kontsa XIX v. Posobiye dlya uchiteley*, (History of Chemistry. Development of Chemistry from Ancient Times to the End of the XIX Century. A Handbook for Teachers), contains, among other, information that Scheele received and described "fire air"[8] (oxygen) properties earlier than Priestley (Soloviev, 1983, p. 71).

In 1998, a book written by the French author Jean-Pierre Poirier entitled *Lavoisier. Chemist, Biologist, Economist* was published in English in Philadelphia (USA). Poirier, almost at the threshold of the 21st century, also gives Scheele the priority for the discovery of oxygen. "The list of competitors for the discovery of oxygen was not yet closed however. A modest Swedish researcher, Carl Wilhelm Scheele, had discovered it three or perhaps four year earlier" (Poirier, 1998, p. 76).

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[7] It should be emphasized that Soloviev is the author of many Russian-language scientific biographies, including Swedish chemists Jöns Jacob Berzelius (1779-1848) and Svante August Arrhenius (1859-1927), Dutch chemist Jacobus Henricus van 't Hoff (1852-1911), German chemist Friedrich Wilhelm Ostwald (1853-1932) and British Chemist Sir William Ramsay (1852-1916).

[8] Scheele also called new air (oxygen) "vitriol air", "saltpetre air", "air purissima" or "principium salinum" (Oseen, 1942, p. 107,109, 113, 121; Walden, 1952, p. 22).

State University (Russia), co-authored the book published in 2009, entitled *Istoriya khimii s drevneyshikh vremen do kontsa XX veka* (History of Chemistry from Ancient Times to the End of the 20th Century). They wrote about the priority of Scheele for the discovery of oxygen in Russian, but the English translation is as follows:

> As shown by the historical analysis of the activity of natural scientists in the 18th century, in the discovery of oxygen, J. Priestly was overtaken by an outstanding Swedish chemist Carl Wilhelm Scheele. The Swedish scientist called the gas he received "fire air". Despite the fact that throughout his life Scheele remained a modest apothecary, in scientific knowledge he excelled many eminent academicians of the time (Mittova, Samoilov, 2009, pp. 220–221).

A letter from Scheele to Lavoisier written on September 30, 1774

The letter written in Uppsala on September 30, 1774 by Scheele to Lavoisier, from the nineties of the nineteenth century, remains the object of interest of scientists due to its content. Édouard Grimaux (1835-1900), professor at the Polytechnic School in Paris, published on January 15, 1890, the original French version of this letter in the article entitled *Une lettre inedite de Scheele a Lavoisier* (An unpublished letter from Scheele to Lavoisier). In the letter, Scheele[9] asks Lavoiser to carry out an experiment involving the purchase of an "air fire" (oxygen) by means of burning glass. Scheele also asks for Lavoisier to inform him about the results of this experiment (Grimaux, 1890, pp. 1–2).

French chemist, Mrs. Josette Fournier, retired university professor, proposed to put this letter on the Internet. On the website *Mediachimie*, in short information about this letter, she wrote that it is "unique, touching and humble" (Fournier, 2018). The author of this article believes that after reading this letter, we should fully agree with it. A fragment of Scheele's letter to Lavoisier from September 30, 1774, translated from French to English, is as follows:

> Sir, (…) Although I do not have the honor of being known by you, I am taking the liberty of thanking you very humbly. I desire nothing with as much ardor as to be able to show you (sic) my gratitude. (…) Because I do not have a big burning glass, please try it with yours this way. Dissolve silver in nitrous acid and precipitates it with alkaline tartrate [potassium carbonate], wash this precipitate, dry it, and reduce it [silver carbonate] with the burning glass in your machine fig.8; but because the air in this bell jar is such that the animals die in it and a part of the fixed air separates from the silver in this operation, it is necessary to put some quick lime [calcium oxide] in the water where one has putt the bell, so that this fixed air [carbon dioxide] joins faster with the lime. It is by this mean that I hope that you will see how much air is produced during this reduction, and whether a lighted candle can sustain the flame and the animals live within it. I will be infinitely obliged if you let me know the result of this experiment. I have the honor to be always with great esteem, Sir, Your very humble servant. At Upsale, September 30, 1774. C.W. Scheele (Grimaux, 1890, p. 1–2).

Figure 8, which Scheele mentions in his letter, is among many other drawings, at the end of the book by Lavoisier, entitled *Opuscules Physiques et Chimiques* (Physical and Chemical Opuscules). It illustrates the experiment carried out by Lavoisier with the minium (Lavoisier,

[9] In the introduction of the letter, Scheele wrote a few words of thanks for a book which Lavoisier sent him. "When Lavoisier published his *Chemical Opuscules*, which appeared in January 1774, he sent copies to a large number of scientists: Bergman, Scheele, Franklin, Guyton de Morveau, Priestley, etc., as well as to the French and foreign Societies" (Grimaux, 1890, p. 1).

1774, (pp. 256–265). Lavoisier used in it, the big burning glass, made by Tchirnausen (Tschirnhaus)[10], belonging to Mr. Count de la Tour d'Auvergne[11] (Lavoisier, 1774, p. 257).

In 1957-2015, several authors wrote about Scheele's letter to Lavoisier, dated September 30, 1774. In 1957, chemist Uno Boklund (1897–1975) wrote about this letter in the article entitled *A lost letter from Scheele to Lavoisier* (Boklund, 1957, pp. 39–62). Also historian of science William Arthur Smeaton (1925-2001) wrote about this letter in *History of Science* in 1963 (Smeaton, 1963, p. 54). The final part of this letter, in English translation, quotes Daniel L. Gilbert (1925-2000), scientist from the Laboratory of Biophysics at National Institutes of Health, Bethesda (Maryland, USA), in his book entitled *Oxygen and Living Processes. An Interdisciplinary Approach* published in 1981 (Gilbert, 1981, p. 12). In 1984, Anthony R. Butler in his article in *Chemistry in Britain*, informed the readers about this letter (Butler, 1984, pp. 617–619). James L. Marshall and Virginia R. Marshall, from Department of Chemistry at University of North Texas, Denton (USA), also wrote about this letter (Marshall, Marshall, 2005, p. 13). In their article, the authors confirmed the fiction of information appearing in the literature, about the fact that Madame Lavoisier "intercepted Scheele's letter but hid it from him" (Marshall, Marshall, 2005, p. 13). The full text of this letter, in English, was quoted in 2014 by John B. West, professor of Medicine and Physiology, from School of Medicine at University of California San Diego (California, USA), in his article entitled *Carl Wilhelm Scheele, the discoverer of oxygen, and very productive chemist* (West, 2014, pp. L813–L814). The reader will find this letter also in West's book entitled *Essays on the History of Respiratory Physiology* (West, 2015, p. 118-119).

Jean-Pierre Poirier in his *Lavosier. Chemist, Biologist, Economist*, briefly described the contents of this letter using modern chemical language:

> On September 30, 1774 Scheele thanked Lavoisier for the book and suggested a protocol for producing a large quantity of fire air using burning glasses. It required dissolving silver in nitric acid, precipitating it by using potassium carbonate, washing and drying the precipitate of the silver carbonate and then subjecting it to the fire of the burning glass, taking the precaution of placing a little quick lime under the ball jar to absorb the fixed air discharged during the operation" (Poirier, 1998, pp. 77–78).

He also informed the reader that Scheele's letter remained unanswered.

> Lavoisier received Scheele's letter on October 15, 1774, but he did not answer it. (…) He was undoubtedly very busy, but it seems to be a weak excuse for a man who was usually so punctual in his correspondence. The Swedish historians of sciences have still not forgiven him for what was much more than simple rudeness. It is difficult to disagree with them, wrote Poirier (1998, p. 78).

[10] Ehrenfried Walther von Tschirnhaus (1651–1708), Count of Kieslingswalde and Stolzenberg was born on April 10, 1651 in Kieslingswalde in Saxony (now, Sławnikowice, Poland), on the estate, which his family had owned for 400 years. In between 1676 and -1679, Tschirnhaus first went to France and then to Italy. During this period of his life, he was particularly interested in using mirrors and lenses to produce high temperatures necessary for melting metals and minerals. Most of the time he participated in joint experiments with François Villette (1621-1698) in Lyon (Smeaton, 1987, p. 265), Athanasius Kircherem (1602-1680) in Rome and Manfredo Settala (1600–1680) in Milan. In 1679-1692, the Tschirnhaus was in a family estate. His passion at the time was mathematics. He also devoted a lot of time to the production of large burning glasses. He also carried out experiments using these glasses (Kracht, Kreyszig, 1990, pp. 21–22; Sztejnberg, 2016).

[11] Count Théophile Malo Correct de la Tour d'Auvergne (1743-1800) was the owner of a big burning glass, made by Tschirnhaus. It was about 33 inches (89 cm) in diameter (Poirier, 1998, s. 54; Smeaton, 1987, p. 266).

Scheele's disease and premature death

Thomas Thomson (1773-1852) was a professor of Chemistry in the University of Glasgow. In the second volume of his book, published in 1830, entitled *The History of Chemistry*, briefly described the causes of Scheele's premature death. Thomson also provides the reader with information about the widow of his predecessor[12], Sara Margaretha Pohl (1751-1793), whom Scheele married, on May 19, 1786.

> Scheele fell at last a sacrifice to his ardent love for his science. He was unable to abstain from experimenting, and many of his experiments were unavoidably made in his shop, where he was exposed during winter, in the ungenial climate of Sweden, to cold draughts of air. He caught rheumatism in consequence, and the disease was aggravated by his ardour and perseverance in his pursuits. When he purchased the apothecary's shop in which his business was carried on, he had formed the resolution of marrying the widow of his predecessor, and he had only delayed it from the honourable principle of acquiring, in the first place, sufficient property to render such an alliance desirable on her part. At length, in the month of March, 1786, he declared his intention of marrying her; but his disease at this time increased very fast, and his hopes of recovery daily diminished. He was sensible of this; but nevertheless he performed his promise, and married her on the 19th of May, at a time when he lay on his deathbed. On the 21st, he left her by his will the disposal of the whole of his property; and, the same day on which he so tenderly provided for her, he died (Thomson, 1830, p. 62).

About rheumatism, which attacked C.W. Scheele, as well as his early death, also wrote Sir William Augustus Tilden in the book entitled *Famous Chemists. The Men and Their Work*.

> Up to the age of thirty-five Scheele had enjoyed good health, but he then began to suffer attacks of rheumatism, probably due to exposure to cold in the shed which served as laboratory during the earlier months of his life in Köping. In the autumn of 1785, however, he was attacked with a more persistent disorder of a similar kind, which in a letter he ascribed to gout, "the trouble of all apothecaries." Notwithstanding the pain he suffered, and the frequent fits of despondency which he found even more hard to bear, he still worked on, and in February, 1786, he sent to the Academy a memoir on gallic acid. In March he was recording his observations on the decomposition of nitric acid in sunlight: "I shall repeat these experiments in the summer, and then we shall see how they turn out." But he never saw that summer. His illness, accelerated by a complication of disorders, ended his life on May 26, 1786. The work of the great investigator was thus brought to a close before he had reached his forty-fourth year (Tilden, 1921, p. 60).

Torvard Claude Laurent (1930-2009), who worked before he died as a scientist in Department of Medical Biochemistry and Microbiology at University of Uppsala (Sweden), wrote in the article with the title *What Did Carl Wilhelm Scheele Look Like?*, that Scheele died, "probably due to heart failure caused by rheumatic fever" (Laurent, 2015, p. 37). Another possible cause of Scheele's premature death was given by Johan Fredric Sacklén (1763-1851) in 1833. In his *Sveriges apotekare-historia*, he wrote in Swedish that Scheele was in good health until he was 36 years old. Then it began to worsen as a result of hard work "in cold and drastic pharmacies and laboratories; at the end of the autumn of 1785 he got an embarrassing gout plague and died in Köping 1786 d. May 21" (Sacklén, 1833, p. 256).

[12] Scheele's predecessor was Hinrich Pasher Pohl (1732-1775). Pohl married a 20 year-old Sara Margaretha Sonneman (1751-1793) on December 12, 1771. Sara Margaretha was Pohl's second wife. His first wife, Maria Molin, died in 1769 at the age of 31 (Sacklén, 1833, p. 253).

Jaime Wisniak in an article with a biography of Scheele, published in 2009, wrote:

> He suffered badly from rheumatism and gout; although the nature of his final illness is not known, it is very probable that it was related to a long-term exposure to highly toxic substances such as arsenic acid and hydrogen cyanide. As other chemists of his time, he practiced testing and smelling the different substances he prepared (Wisniak, 2009, p. 166).

Gunnar Svedberg, like Wisniak, wrote about the exposure of Scheele to a very toxic chemical substance: "his premature death at the age of 43 may have been caused by hydrogen cyanide" (Svedberg, 2012, p. 41). John B. West gave one more reason for Scheele's premature death, and like Wisniak and Svedberg, he wrote about the exposure of Scheele to various toxic chemicals. West listed more toxic substances than the previously mentioned authors.

> In 1785, Scheele became ill with symptoms of renal disease. A short time later he developed a disease of the skin although its nature is not clear. (…) Scheele had developed a habit of tasting various chemicals that he worked on. Since these included arsenic, lead, and other toxic materials, it has been suggested that these were a factor in his demise (West, 2014, p. L816; 2015, pp.122–123).

Opinions about C.W. Scheele expressed by chemists between 1819 and 1942

British chemist Sir Humphry Davy (1778-1829) in his book entitled *Elements of Chemical Philosophy* characterized Scheele in the following way:

> Scheele possessed in the highest degree the faculty of invention; all his labours were instituted with an object in view, and after happy or bold analogies. He owed little to fortune or to accidental circumstances: born in an obscure situation, occupied in the duties of an irksome employment, nothing could damp the ardour of his mind or chill the fire of his genius: with very small means he accomplished very great things. No difficulties deterred him from submitting his ideas to the test of experiment. Occasionally misled in his views, in consequence of the imperfection of his apparatus, or the infant state of the inquiry, he never hesitated to give up his opinions the moment they were contradicted by facts. He was eminently endowed with that candour which is characteristic of great minds, and which induces them to rejoice as well in the detection of their own errors, as in the discovery of truth. His papers are admirable models of the manner in which experimental research ought to be pursued; and they contain details on some of the most important and brilliant phænomena of chemical philosophy (Davy, 1812, p. 38–39).

A beautiful text of praise in honor of Scheele was written by John Gorham (1783-1829), member of the American Academy, professor of Chemistry at Harvard University, Cambridge (USA), in a book entitled *The Elements of Chemical Science*, published in Boston.

> It was not the least of his merits that he perceived and fostered the rising genius of Scheele. Born in a humble station of life, this admirable man rose by his own industry and powers of mind to the highest rank among the chemists. Engaged at an early period of his life in the study of the science, he devoted to it all his thoughts, and may be said to have lived in his laboratory. (…) The labours of this great chemist were immense. Though he died at the early age of 44 years, he made more discoveries, and brought to light a greater number of important facts, than any chemist of a former, and perhaps also of a succeeding age. He first pointed out the nature of manganese; he obtained and

> demonstrated the nature of oxy-muriatic gas, or chlorine; developed the properties of barytes, and was the discoverer of oxygen and azote. The knowledge of the nature of tungsten, of molybdena, prussian blue, and a number of the important vegetable acids, we also owe to his sagacity. Besides all these, his Treatise *on Fire and Air* contains most of the important facts which are now known on the subject of *Radiant Heat*, and the chemical action of light; and the details of the experiments by which he arrived at the discovery, both of *Empyreal air*, or oxygen gas, and of *Foul air*, or azote (Gorham, 1819, p. XXIX–XXX).

Very interesting opinions about C. W. Scheele were given in chemical literature also by many other chemists and chemistry historians. One of them was Thomas Thomson. In his *The History of Chemistry*, he wrote about several of his advantages:

> I have already observed, that we are under obligations to Bergman[13], not merely for the improvements which he himself introduced into chemistry but for the pupils whom he educated as chemists, and the discoveries which were made by those persons, whose exertions he stimulated and encouraged. Among those individuals, whose chemical discoveries were chiefly made known to the world by his means, was Scheele, certainly one of the most extraordinary men, and most sagacious and industrious, chemists that ever existed (Thomson, 1830, p. 53).

In 1886, in Sweden, Per Teodor Cleve (1840-1905) in his *Carl Wilhelm Scheele: ett minnesblad pa° hundrade årsdagen af hans död* (Carl Wilhelm Scheele: A Memory Sheet on the Centenary of His Death) wrote in Swedish his opinion about Scheele. A translation into English is as follows:

> It is amazing that one man who did not reach the age of 43, during his short life and with little help, could achieve so much, conducting deeply involved research in all areas of chemistry. Thanks to these discoveries, he became a man of honor, and he contributed the most to the respect and reputation that our country enjoys among nations that promote research, expand knowledge and contribute to the development of humanity (Cleve, 1886).

Jean-Baptiste Dumas (1800-1884), in his book published in 1837, entitled *Leçons sur la philosophie chimique* (Lessons on the Chemical Philosophy), wrote in French about Scheele. A translation is as follows:

> His skill made up for everything, and with limited equipment, he knew how to make the most delicate experiments, isolate the best hidden bodies, produce the most unexpected compounds and to rise to the most important discoveries. Nature seemed to want to console him for the misfortunes inflicted on him by men, and to delight in sharing with him its most beautiful secrets. He did not touch a body without making a discovery (Dumas, 1837, p. 94).

In 1863, Paul Antoine Cap (1788-1877) in his *Scheele, chimiste suédois: étude biographique* (Scheele, Swedish Chemist: Biographical Study) listed several personality characteristics of Scheele. He saw in him person a humble, persistent, with great talent, a true scientist with a large number of important discoveries. Scheele, in his opinion "was great and famous in the eyes of all without ever being in his own eyes" (Cap, 1863, p. 8).

[13] Torbern Bergman (1735-1784) was professor of chemistry at Uppsala University (Sweden).

According to Ferdynad Hoefer (1811-1878), Scheele was an outstanding experimenter. In his book entitled *Histoire De La Chimie*, he wrote in French, but the English translation is as follows: "Few chemists had yet penetrated so far into the secrets of nature as Scheele. He had the genius of discoveries [Il avait le génie des découvertes]; no detail escaped his searching gaze" (Hoefer, 1869, p. 450).

George Rantoul White, Instructor in Chemistry at Phillips Exeter Academy (USA) in his *An Elementary Chemistry* rated Scheele's work highly:

> *A remarkable power of observation, an extreme diligence, and an ability to plan experiments* which should bear directly on the question in hand and give decisive results in the quickest and simplest way, have given Scheele a high rank among chemists of all lands and all times (White, 1894, p. 152).

In 1898, Ernst von Meyer in his *A History of Chemistry from Earliest Times to the Present Day* wrote very favourably about Scheele:

> Karl Wilhelm Scheele will remain for all time one of the most distinguished of chemists; and his fame is not lessened by the fact that he continued all his life through a zealous supporter of the phlogistic doctrine. In spite of this fact, of the unfavourable conditions under which he lived, and of the short span of his life, he contributed to chemistry a wealth of new observations many of them discoveries of supreme value which furnished a rich mine for the experimental work and theoretical discussions of future generations (Meyer, 1898, p. 125).

At the end of a short biographical note, Meyer listed some of the personality traits characteristic for Scheele:

> It is not merely as an investigator and discoverer, but as a high-principled and unassuming man, that Scheele merits our warmest admiration. His aim and object was the discovery of the truth. The letters of the man reveal to us in the pleasantest way his high scientific ideal, his genuinely philosophic temper, and his simple mode of thought. "It is the truth alone that we desire to know, and what joy there is in discovering it!" With these words he himself characterises his own efforts (Meyer, 1898, p. 126).

George Augustus Cornish (1872-1960) in his book entitled *The Ontario High School Chemistry*, published in 1917, highly appreciated Scheele's experimental skills.

> He was apprenticed at fourteen to an apothecary in Gothenburg. Later he was proprietor of a pharmacy at Köping. Despite a life of constant hardship, the record of his discoveries is unparalleled. Most of his work was accomplished at the end of busy days, in narrow chambers, with apparatus of his own inventing; but the spirit within him was unquenchable. He stands unique among experimental investigators, his dexterity in manipulation being unsurpassed (Cornish, 1917, p.156).

Henrik Gustaf Söderbaum (1862-1933) in his *Some notes of Carl Wilhelm Scheele* wrote:

> Scheele had no university education and no very extensive learning, and for the greater part of his life he had to work under unfavourable external circumstances and to content himself with the simplest resources. But he made up for these drawbacks by a wonderful power of observation and an unappeasable thirst for knowledge, which, in combination with indefatigable endurance, led him to an unprecedented mastership in

> the art of chemical work (Söderbaum, 1926, p. 66).

Ralph Edward Oesper (1886-1977) wrote about Scheele:

> Although Scheele's fame rests upon his remarkable genius for discovering and isolating new elements and compounds, it must not be forgotten that he was a lifelong practitioner of pharmacy. Apprenticed to this profession, by his own choice, when not yet fifteen he remained true to this calling even after he had earned an international reputation as a chemist. Glittering offers from the court, from the scientific center of his native country, from foreign rulers, from industrial corporations, all were unhesitatingly rejected. He preferred to pursue the easy tenor of his life as the proprietor of an apothecary shop in a small town. From this modest station in life he derived a high degree of satisfaction from a task well done and when his vocation permitted he worked at his beloved hobby, chemistry (Oesper, 1934, p. 483).

George Urdang (1882-1960), in his P*ictorial Life History of the Apothecary Chemist Carl Wilhelm Scheele* wrote: "The authority which Scheele enjoyed was so great, and his honesty and simplicity of character so obvious and disarming, that none of the usual scientific jealousies and quarrels ever touched him" (Urdang, 1942, cited by Weeks, 1960, p. 224).

CONCLUSIONS

Obverse of the medal minted by the Royal Swedish Academy of Sciences in 1789, includes the Latin inscription: "Carolus Wilh. Scheele Chemicus" and the name of its creator - I. C. Wikman. On the reverse are the words: "*Ingenio stat sine morte decus*" (His genius makes his fame immortal) (Laurent, 2015, p. 37). The immortality of Scheele's fame is demonstrated by the fact that he is the object of interest of scientists in many countries in the world, including not only chemists and chemists historians, but also pharmacists and physicians. Scheele's biographies were written in the 19th and 20th centuries. Also in the 21st century, in the literature are bibliographic notes about him. It can be predicted that scientists, from next generations of humanity, will never forget about him and his achievements, and he will be admired, and his discoveries will be praised by scientists, also in the distant future.

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