Wilhelm Ostwald

DOI: 10.1002/anie.200901193

Wilhelm Ostwald: Founder of Physical Chemistry and Nobel Laureate 1909

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heterogeneous catalysis · history of chemistry · Nobel Prize · Ostwald, Wilhelm · physical chemistry

A Surprised Laureate

"*I am both pleased and surprised that the highest scientific distinction that there is today has been awarded in recognition of my studies of catalysis, of all the studies through which I have sought to extend the field of general chemistry. Pleases me because in my innermost being I have always considered this area to be the one in which my personal approach is most evident, and for that reason it is nearer to my heart than all the others. Surprises me, because I did not expect to receive this much-hoped-for recognition until a much later date.*" [1][*]

This is a paraphrase of the beginning of the lecture that Wilhelm Ostwald (Figure 1) held on December 12, 1909 in Stockholm, two days after he had been awarded the Nobel Prize for Chemistry. The prize had been awarded "in recognition for his work on catalysis and for his investigations into the fundamental principles governing chemical equilibria and rates of reaction" as it is explained on the associated diploma (Figure 2).

Ostwald's surprise can certainly be understood. In the preceding years he had made a series of fundamental discoveries in so many different areas of the rapidly developing field of physical chemistry that he can be justifiably be regarded as the founder of this discipline. It is true that other representatives of this area had already been honored with the Nobel Prize: The first Nobel Prize for Chemistry went to J. H. van't Hoff in 1901 "in recognition of his discovery of the laws of chemical dynamics and osmotic pressure in solution", and in 1903 S. Arrhenius was honored for his theory of electrolytic dissociation. But in addition to his own fundamental contributions Ostwald had published the first systematic compilation of his subject, the seminal two-volume

Figure 1. Wilhelm Ostwald in about 1897.

Figure 2. Nobel Prize diploma for Wilhelm Ostwald.

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[*] "Dass die höchste wissenschaftliche Auszeichnung, die es gegenwärtig gibt, unter den vielerlei Arbeiten, durch welche ich das Gebiet der allgemeinen Chemie zu erweitern mich bemüht habe, gerade denen über Katalyse zuerkannt worden ist, hat mich ebenso beglückt wie überrascht. Beglückt deshalb, weil ich in meinem eigenen Inneren diesen Teil meiner Tätigkeit für den hielt und halte, in welchem sich die persönliche Beschaffenheit meiner Arbeitsweise am bestimmtesten ausspricht und der mir deshalb mehr als alle anderen am Herzen liegt. Überrascht, weil ich erst von einer sehr viel späteren Zeit die Anerkennung erwartete, auf welche ich hierfür hoffen durfte".

Lehrbuch der allgemeinen Chemie,[2] and in 1887 in collaboration with van't Hoff he founded the *Zeitschrift für Physikalische Chemie*. Finally he established a large scientific school, from which most physical chemists at that time originated.

Every chemistry student today is familiar with a list of terms associated with the name Ostwald, the Ostwald dilution law, the Ostwald rule, Ostwald ripening, and the industrial Ostwald process. In his time physical chemistry was based essentially on thermodynamics after the first and second fundamental laws had been discovered in the 19th century. Thus the term "energy" was a general guiding principle for Ostwald, and it was not a coincidence that he called his country estate in Grossbothen, to which he retired after leaving the University of Leipzig, "Haus Energie". His primacy of energy ("*Do not waste energy, utilize it.*") was indeed criticized during his lifetime, but today it possesses an urgent topicality. Ostwald made important contributions to the emerging fields of electrochemistry and reaction kinetics. In contrast he took a skeptical stance towards the idea of an atomic construction of materials and was one of the most prominent opponents of L. Boltzmann—an attitude he revised only in later life, without, however, attaching value to the then emerging quantum theory.

Besides his prominent role as a researcher and teacher Ostwald was characterized by sheer inconceivable creativity in many areas; he can certainly be called a workaholic: he produced 45 books and roughly 1000 publications. He was also the editor of important journals and series of books as well as the founder of scientific societies; he was interested in natural philosophy and history of science, and late in life he developed his own theory of color. The impetus for the latter activity was certainly his preoccupation with painting, which he pursued as a recreation and which was evident in the numerous landscapes in his estate.

He divided his activities into two working areas, that of the discoverer and that of the organizer, whereby he considered the organizer to be more important:[4] "*The organizer builds roads, the researcher tends to his garden. However, an organizer in science can only be someone who was also a discoverer since otherwise he has no measure for that which he will organize. The reverse is not necessary, for the majority of discovers lack organizational ability*".[*]

"Lebenslinien"

This was the title of Ostwald's three-part autobiography published in 1926/27,[3] which under the auspices of the Sächsischen Akademie der Wissenschaften was republished a few years ago in an edition revised and annotated by K. Hansel.[4] Ostwald as a person was described by his daughter, Grete Ostwald, in a somewhat glorified form in a book published in 1953.[5]

Wilhelm Ostwald was born on the September 2, 1853 in the then Russian city of Riga as the second of three sons of the ethnic German master cooper Wilhelm Gottfried Ostwald and his wife Elisabeth, née Leuchel. After attending elementary school and high school he began his chemistry studies at Dorpat University in 1872. His interest in chemistry had already been awakened during his school years. This, together with other activities, meant he was only able to complete his Abitur after a delay of one and a half years. His chemistry teachers at the university were Johann Lemberg and Liebig's pupil Carl Schmidt, while Arthur von Öttingen was responsible for physics. Although Ostwald somewhat idled away the initial semesters, he obtained the degree of Magister in 1877 and a year later graduated as Doctor of Chemistry.

Meanwhile his interest in science had become so deep-rooted that he was overjoyed when he was offered a position of assistant to von Öttingen. Later he switched to an analogous position with Carl Schmidt, with whom he attained his Habilitation in 1880. Since he married in the same year, he needed to earn some money for his new household; in addition to his assistant activities he took on the position of teacher in a high school. His financial cares ended in 1882 when at the age of 28 he received an invitation to Riga Polytechnic as Professor of Chemistry; with that he left Dorpat after ten years and returned to his hometown.

There he immediately immersed himself in his new work, and he himself reported a conversation between two Polish students: "*Have you already heard new professor? – No. Why? – You must hear. He puts chemistry into your head as if with shovel.*" In research Ostwald turned to the area of thermodynamics (or "energetics" as he called it), which was blossoming after the discovery of the two laws. In addition to studying equilibria he also included reaction rates, and for these experiments he developed a series of apparatus, in particular the thermostat, which is even illustrated on the Nobel Prize certificate. To accommodate the inflow of students a new building became necessary, and to obtain the building permit Ostwald first had to undertake a tour of Germany to get an impression of the most important laboratories. During this four-week journey he made the acquaintance of all the leading scientists active in chemistry. The new laboratory was finally built and, after what is by today's standards a short construction time, Ostwald moved in 1885.

Ostwald's time in Riga was a phase of the most demanding activity: he wrote the monumental two-volume textbook, and with the move to topics in electrochemistry he took up a new current research area, which was fostered by the close contacts with Arrhenius and van't Hoff, and finally the first issue of the *Zeitschrift für Physikalische Chemie* appeared on the February 15, 1887.

Meanwhile the situation in Riga had become too restrictive for Ostwald and he sought another workplace (in Germany). Leipzig was attractive, as the university offered the only chair for physical chemistry in Germany. This position had become vacant because its occupant Wiedemann moved to the chair for physics. After negotiations with a

[*] "Der Organisator baut an der Straße, der Forscher pflegt seinen Garten. Ein Organisator in der Wissenschaft kann aber nur einer sein, der auch Entdecker war, da er sonst keinen Maßstab für das besitzt, was er organisieren will. Das Umgekehrte ist nicht nötig, denn einem großen Teil der Entdecker fehlt die organisatorische Fähigkeit".

series of other candidates had failed, Ostwald received the invitation which he accepted at the age of just 34. And so in September 1887 he and his family, now with four children, migrated from Russia to Germany. During the same period the discoveries of the fundamental laws of osmotic pressure by van't Hoff and electrolytic dissociation by Arrhenius were made. Ostwald supplemented these with his dilution law, and the area of physical chemistry was placed on a firm footing. From then on Ostwald too concentrated his research activity mainly on electrochemistry.

The new institute, referred to as the Second Chemical Laboratory, comprised three departments, each with an assistant. Ostwald procured Walter Nernst for the physical chemistry department; he was employed with an annual salary of 1000 marks and, as is well known, became another of the leading lights of his discipline.

Ostwald continued to manage an almost unimaginable workload: in addition to his teaching responsibilities and his own research work he wrote extensively. He wrote textbook after textbook and began with the publication of the series *Ostwalds Klassiker der exakten Wissenschaften*, for which he contributed many translations as well as his own work. He also started to use a typewriter, through which he increased his rate of writing still further. He proudly commented that on a peaceful Sunday he completed a translation of 67 printed pages in this way.

At that time Ostwald developed his thoughts increasingly on "energetics", according to which all observable processes in the world are ascribable to the associated energy. Many of these ideas appear trivial to us today, others in turn far-fetched. And it was thus inevitable that heated discussions arose. In addition there was Ostwald's rejection of atomic theory, and this disagreement reached a culmination at the meeting of the German Gesellschaft der Naturforscher und Ärzte in Lübeck in 1895,[6], at which Ostwald formulated his viewpoint as follows: "*However, if the concept of atoms in motion is taken from us how should we represent reality? To such a question I would like to respond: you should not make unto yourselves an image or allegory!*"[*] This was the essence of the natural philosophy represented by Ernst Mach, which finally also destroyed Ludwig Boltzmann emotionally.

At almost the same time as this intervention of Ostwald, Röntgen discovered the radiation that was later named after him;[7] finally the atomic structure of matter was established experimentally, and it must be stated in Ostwalds's defense, that he later modified his attitude on this problem: "*I am convinced that we recently gained experimental proof for the discrete or granulous nature of matter, which the atom hypothesis had sought without success for centuries*".[8] [*]

[*] "Aber, wenn uns die Anschauung der bewegten Atome genommen wird, welches Mittel bleibt uns übrig, uns ein Bild von der Wirklichkeit zu machen? Auf solche Frage möchte ich rufen: Du sollst dir kein Bildnis oder Gleichnis machen!"

[*] "Ich habe mich überzeugt, dass wir seit kurzer Zeit in dem Besitz der experimentellen Nachweise für die diskrete oder körnige Natur der Stoffe gelangt sind, welche die Atomhypothese seit Jahrhunderten vergeblich gesucht hatte".

As Ostwald had accepted the invitation to Leipzig without making further stipulations, he had to come to terms at first with the very unsatisfactory space limitations of his institute; this changed in 1894 with the approval of a new building. Ostwald fell seriously ill during the building phase with what one would today call burnout syndrome. He recovered after an extended convalescence; however, an aversion for teaching remained.

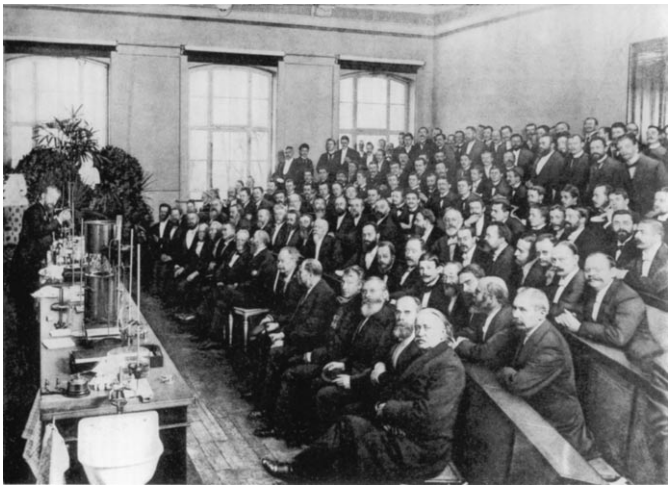

Figure 3. Opening of the Physikalisch-Chemisch Institut in Leipzig in 1898.

The new building was completed in 1897 and was opened ceremoniously before a large audience on January 3, 1898 under the name "Physikalisch-Chemisches Institut" (Figure 3). During his lecture on this occasion Ostwald experimented with liquid air, the production of which had been carried out shortly before by Carl von Linde. However, the lecture concentrated more on philosophical questions—an area that interested Ostwald increasingly. Starting in 1901 he regularly held lectures on natural philosophy, and he founded the journal *Annalen der Naturphilosophie*. During those years his co-workers included, in addition to Nernst, such illustrious scientists as Georg Bredig, Max Bodenstein, Alwin Mittasch, and Herbert Freundlich. He also made two journeys to the USA—at that time a strenuous and time-consuming undertaking—and he received numerous awards during this period.

Regardless of his continuing literary activities, the job of teaching became increasingly averse for Ostwald. His contemporaries had the impression that even his interest in chemistry generally declined so that in the end he actually avoided scientific discussions. Because of his increasing exhaustion he applied for a leave of absence from his teaching activities. This request unleashed considerable opposition in his Philosophic Faculty and was there refused. After this Ostwald requested to resign for "health reasons" with his letter of February 26, 1905. Thereupon the ministry sent him an invitation to go to Harvard University as the first German exchange professor with the suggestion then to serve for another semester in Leipzig, through which his pension would

also be increased. The four-month USA stay was filled with numerous lectures (in English), which Ostwald clearly enjoyed—in contrast to the last semester which he subsequently still had to "serve out" in Leipzig.

Through his numerous books Ostwald had become rather wealthy, so that as early as 1901 he had acquired extensive property in Grossbothen, 40 km from Leipzig, which was now developed into his country estate "Energie"; this home and retreat became the center of the new chapter in his life as a private scholar. It was there that the news of the award of the Nobel Prize reached him in 1909 as a 56-year-old—at a time when he had long not occupied himself with actual chemistry.

Catalysis

Since antiquity it had been known that the addition of the tiniest amounts of material could greatly affect the composition of other materials. During the Middle Ages this action was attributed to the "philosopher's stone", whence it was a long way to the fundamental explanation of this phenomenon by Wilhelm Ostwald.[9] The term "catalysis" had been coined by the Swedish chemist Berzelius, who, in his annual reports published starting in 1820, had repeatedly referred to such findings but only in 1835 introduced suitable terminolgy:[10] "*In order to avail myself of a derivation well-known in chemistry I will call both the catalytic force of matter and the decomposition by this matter, catalysis, just like we understand with the word analysis the separation of the constituents.*"[*]

In the time that followed, the existence of this phenomenon was not questioned, although attempts at its explanation during the second half of the 19th century were vigorously disputed, especially by Liebig. A turning point in the discussion was only reached by Ostwald. The following definition, published in 1894, can be regarded as the first indication made by him of the relationship of catalysis with the new area of reaction kinetics: "*Catalysis is the acceleration of a slow chemical process by the presence of a foreign material*".[*][11] The state of knowledge on the topic of "catalysis" at that time was described in detail by Ostwald in the text *Ältere Lehre von den Berührungswirkungen* which appeared in 1897/1898.[12] Remarkably, this historical chemical work was a "dissertation" submitted to the Philosophical Faculty of the University of Leipzig although the author was already a multiple doctor, full professor and actually the current dean!

Ostwald first recognized catalysis as a kinetic phenomenon in the explanation of his 1887 investigations on the oxidation of hydrogen iodide by bromic acid as he highlighted in his Nobel Prize lecture:[1] "*I was compelled to the view that the nature of catalysis is not in the induction of a reaction, but in its acceleration… I would be honest if I were to omit the fact that even at that time I was not particularly impressed at all by this advance.* [*]

As a consequence of his thoughts on the nature of catalysis Ostwald eventually presented his final definition in a lecture at the meeting of the Gesellschaft Deutscher Naturforscher und Ärzte on September 26, 1901: "*A catalyst is a material that changes the rate of a chemical reaction without appearing in the final product.*"[13][*] Ostwald still had no clear perception on the actual origin of this phenomenon. He certainly presumed that the formation of an intermediate compound between the catalyst and the molecules involved in the reaction played a role, but said "… *until a way has been found whereby the rate of chemical reaction can generally be calculated in advance, the catalysis problem cannot satisfactorily be answered.*"[1][*] The identification of the intermediates on an atomic scale succeeded experimentally only recently through the development of a whole arsenal of physical surface methods, and a quantitative treatment succeeded thanks only to the corresponding advances of theory.[14]

At about the same time as the preparation of the aforementioned dissertation[12] and the move to the new institute building, Ostwald began to turn to the practical applications of catalysis. Owing to the continually growing world population and the exhaustion of natural fertilizers (guano) towards the end of the 19th century, the artificial production of nitrogen fertilizers became a global challenge of similar dimensions as the question of climate change today. The problem of nitrogen fixation was solved in the laboratory by Fritz Haber in 1909, and Carl Bosch succeeded in converting the method into an industrial process. In 1913 ammonia was produced on an industrial scale for the first time (Haber–Bosch process). The iron catalyst necessary for this reaction had been developed previously by the Ostwald student A. Mittasch and is still in use in almost unchanged composition in production plants worldwide.

Ostwald had been preoccupied with the question of catalytic nitrogen fixation since 1900.[15] Investigations by his co-workers Bodenstein and Brauer with heated iron wire produced positive results, so that in March 1900 Ostwald drafted a corresponding patent. During a visit to BASF in Ludwigshafen the astronomical sum of three million marks was considered as compensation for Ostwald. Unfortunately it soon emerged that ammonia did not form from N_2 by catalysis but from the reaction of nitrogen dissolved in the iron, and the whole dream collapsed. Not without bitterness

[*] "Ich werde sie daher, um mich einer in der Chemie wohlbekannten Ableitung zu bedienen, die katalytische Kraft der Körper und die Zersetzung durch dieselbe Katalyse nennen, gleichwie wir mit dem Wort Analyse die Trennung der Bestandteile verstehen."

[*] "Katalyse ist die Beschleunigung eines langsam verlaufenden chemischen Vorgangs durch die Gegenwart eines fremden Stoffes".

[*] "So wurde ich unwiderstehlich zu der Auffassung gedrängt, dass das Wesen der Katalyse nicht in der Hervorbringung einer Reaktion zu suchen ist, sondern in ihrer Beschleunigung... Ich würde der Pflicht der Aufrichtigkeit zuwider handeln, wenn ich unterlassen würde, zu bemerken, dass mir selbst damals dieser Fortschritt keineswegs besonders imponierte."

[*] "Ein Katalysator ist jeder Stoff, der ohne im Endprodukt einer chemischen Reaktion zu erscheinen, ihre Geschwindigkeit verändert."

[*] "... solange die Frage nach der allgemeinen Vorausberechnung einer chemischen Reaktionsgeschwindigkeit noch nicht gelöst ist, kann eine ausreichende Antwort auf die katalytische Frage nicht gegeben werden.

Ostwald commented later that he considered himself the intellectual father of this industry without it being correspondingly appreciated (at least by A. Mittasch).

Ostwald was more successful in the realization of his next goal, the oxidation of ammonia to nitrogen oxides as precursors for the production of nitric acid. He was encouraged by a conversation in which the dependent position of Germany was discussed were England to block the import of Chile saltpeter (sodium nitrate) necessary for the production of gunpowder; starting in the fall of 1901 he examined the possibility of producing sodium nitrate industrially. He charged his future son-in-law, Eberhard Brauer, with undertaking the necessary experiments, whereby it soon became clear that the contact time with the platinum catalyst must be as short as possible in order to avoid the formation of $N_2 + H_2O$ as the energetically lowest state.

After several conflicts and diversions a plant was finally built in Bochum under the direction of Eberhard Brauer which from 1906 "*regularly produced nitric acid and ammonium nitrate on an industrial scale and with good profit*".[16]

As early as 1909 finely woven platinum gauze was used as the catalyst (today a platinum/rhodium gauze is used), and in 1915 a facility with a capacity of 150 tonnes nitric acid was commissioned by BASF.[17]

Electrochemistry

At the beginning of his career as a researcher Ostwald had devoted himself to the study of the conductivity of solutions in addition to the study of the kinetics of chemical reactions. Ostwald, van't Hoff, and Arrhenius can all be considered founders of the field of electrochemistry, which was established in 1887 when Arrhenius published his theory of the electrolytic dissociation of ions in the first volume of the new *Zeitschrift für Physikalische Chemie*.[18] Ostwald had already come up with the basic idea, revolutionary at that time, ten years earlier in his Magister dissertation when he formulated the thesis "*water decomposes all salts*".[19] The conductance measurements he carried out after Arrehnius's publication then led to the formulation of his famous Dilution Law.[20] During the initially bitter dispute on the theory of electrochemical dissociation its adherents remarkably also received the support of the young Max Planck.[21] A short time later Ostwald's assistant Walter Nernst developed his theory of electromotive activity of ions in his Habilitation dissertation with the help of the Nernst equation.[22]

A series of discoveries at that time gave rise to the rapid expansion of electrotechnology, which together with the new knowledge led in turn to an enormous upsurge in electrochemistry. In 1893 this prompted Ostwald to begin with the writing of his next large work, which appeared in 1896: *Elektrochemie*.[23] Even the title picture (Figure 4) reflected the great hope placed on this new area.

In this 1150-page book Ostwald did not restrict himself to the elucidation and explanation of scientific findings but also went into the historical development in detail and the biographies of leading researchers. He justified this approach in the foreword as follows: "*A recurring experience for me both as a researcher and a teacher has shown that there is no more effective means for enlivenment and consolidation of study than the penetration into the historical background of the problem.*"[*] This can also be regarded as an indication that occupation with his specialist knowledge alone had become too narrow, as was confirmed in his later autobiography. In his own estimation he considered *Elektrochemie* to be one of his best works.

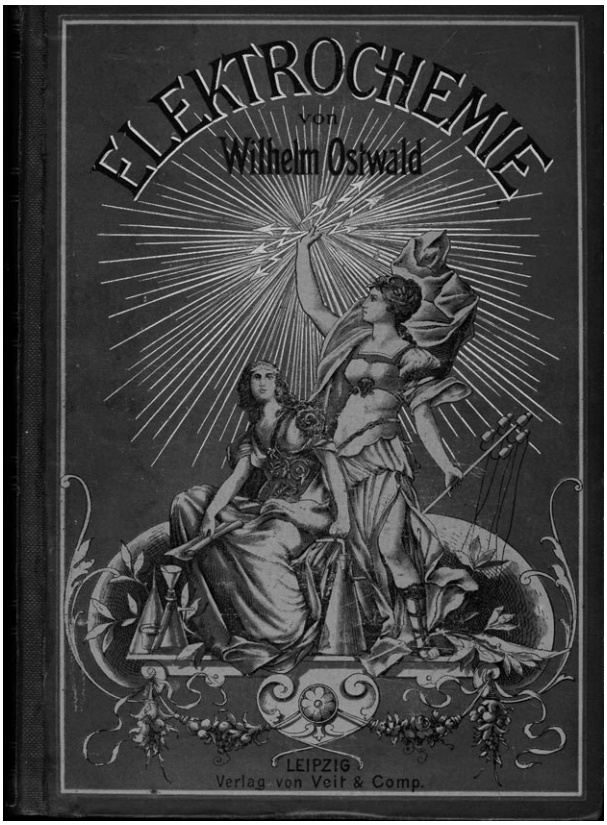

Figure 4. Cover page of *Elektrochemie* 1896.

During the writing of *Elektrochemie* Ostwald was approached to form a Elektrochemische Gesellschaft, which he did in 1894. Ostwald was elected as the first president. He was never truly happy in this role and consequently resigned in 1898, when van't Hoff took over this position. Finally it was Ostwald's turn again in 1902, when on his initiative[24] the society was renamed as the Bunsen Gesellschaft.

Meanwhile electrochemistry had achieved such a status that newly founded institutes frequently got the name "… für physikalische Chemie und Elektrochemie". One example was the the first Kaiser-Wilhelm-Institut founded in 1911 in Berlin, which later became the Fritz-Haber-Institut.

[*] "Eine stets wiederkehrende Erfahrung als Forscher wie als Lehrer hat mich überzeugt, dass es kein wirksameres Mittel zur Belebung und Vertiefung des Studiums gibt als das Eindringen in das geschichtliche Werden der Probleme."

Großbothen

Ostwald turned away gradually from his teaching duties at Leipzig University. As early as 1900 he arranged for the appointment of a deputy director (Robert Luther) for his institute who was responsible for the day-to-day business, while he shifted his own emphasis to natural philosophy, where Ernst Mach became his role model. Ostwald was almost obsessed with his idea of "Energetics"—a principle based essentially on the first law of thermodynamics and whose conflicts are today still difficult to comprehend. Ostwald formulated the quintessence of his ideas with his energetic imperative "*Do not waste energy, utilize it*"—a formula that is even more topical today than it was then. At the same time Ostwald received a series of gratifying honors: in 1903 his first journey to California and the 25-year jubilee of his doctorate, in 1904 the Faraday Lectureship, and finally in 1905 the invitation to Harvard as an exchange professor. The invitation to a Congress of the Arts and Sciences in St. Louis in 1904 as part of the World Fair must have been a special event for him where he appeared as philosopher and not as chemist. During his four-month stay in Harvard the construction work on his estate "Energie" proceeded, and his family took up residence in September 1906. Figure 5 shows the main building, "Haus Energie", in which Ostwald worked in the laboratory and library until his death in 1932. By additional acquisition the estate was enlarged to seven hectares, and the development extended to five houses.

Figure 5. "Haus Energie" in Großbothen.

At first Ostwald concentrated there on a whole series of problems that had been going through his head for some time: this included his classification of researchers as classicists or romantics and their analysis by "psychographs". This culminated again in a book with over 400 pages, *Große Männer*,[25] which he considered as studies on the biology of genius. He was also involved in educational reform and the introduction of a new world language "Ido" that was to replace Esperanto.

Soon afterwards Ostwald was approached with the next task: the meanwhile aged biologist and philosopher Ernst Haeckel, a staunch supporter of Darwinism, had founded the Deutsche Monistenbund in 1906. Monism describes a doctrine according to which all observed phenomena in the world may be ascribed to a single underlying principle, the principle of the unity of nature and spirit. The Monistenbund was in strong opposition to the church. In 1911 Ostwald was elected president of the Monistenbund. His involvement was primarily responsible for the enormous popularity of the Bund meetings before the First World War. With the outbreak of the war Ostwald assumed an antipacifistic and nationalistic position, which brought him under considerable pressure from the side of the pacifistically disposed forces in the Monistenbund, so that he resigned as president in 1915. But Ostwald did not even begin to get bored. He was involved with a worldwide organization of chemical societies, the standardization of paper formats, and above all with the formation of the "Brücke", an association for the organization of intellectual work, which, in spirit of the encyclopedists of the Enlightenment, set out to collate and organize all known knowledge. However, an institute founded for this purpose had to close again as early as 1914 owing to lack of funding.

The emphasis of Ostwald's activities after 1914 was in the development of a quantitative theory of colors, which he himself considered the pinnacle of his achievements.[26] The basis for the pursuit of this problem is certainly Ostwald's avocation of painting. Here, too, his energy and activity were boundless: the museum established in his estate "Energie" has about a thousand of his landscapes and innumerable color sketches.

To develop his theory of colors Ostwald once more constructed a laboratory (Figure 6) and later in one of his houses even a small fabrication facility. His work concen-

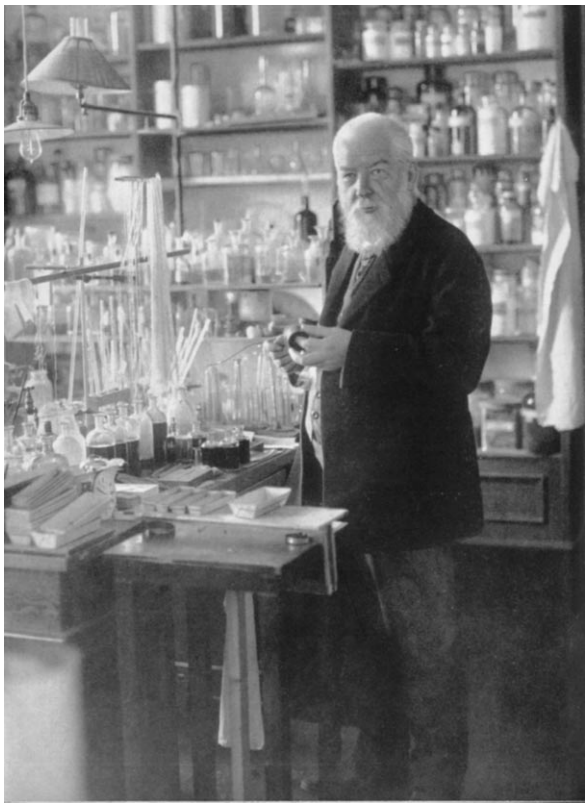

Figure 6. Wilhelm Ostwald at the age of 75 in his laboratory.

trated on attempts to classify colors to such an extent that they would be amenable to quantitative analysis. He was convinced that that he could solve this problem and thus induce a new development in human culture. With continuing self-confidence he was convinced that he would solve a problem at which Goethe and Helmholtz had previously failed. Towards the end of his life he developed his laws of harmony, mainly through the study of flowers, and was also occupied with writing. After a short illness he died in a Leipzig clinic on April 4, 1932, at the age of 78. His ashes were laid to rest in the park of his estate.

The estate "Energie" was maintained as memorial and was presented to the Akademie der Wissenschaften by Ostwald's heirs in 1953. After the German reunification in 1989 it was transferred to the ownership of the State of Saxony. To ensure its continued existence the Wilhelm-Ostwald-Gesellschaft zu Großbothen was founded in 1990 for the preservation of the inheritance. After a long period of uncertainty, the property was finally acquired by the charitable Gerda und Klaus Tschira Stiftung on January 1, 2009. Thanks to the more solid financial footing, it will serve in the future as a meeting site for scientific exchange.

Received: March 3, 2009
Published online: June 17, 2009

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