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Friedrich Wilhelm Ostwald (born 02 September 1853, Riga, Latvia, Russian Empire—died 04 April 1932, near Leipzig, Germany), was a Baltic German chemist and philosopher who contributed enormously to the establishment of modern physical chemistry. In 1887 he was called to the Chair of Physical Chemistry at the University of Leipzig, which was then the only Chair of Physical Chemistry in the world. At Leipzig he pioneered the introduction of equilibrium thermodynamics into the study of chemical systems. Within a few years, he became one of the most celebrated scientists in Europe.

His energy was prodigious. Over his career he published 45 books, 500 scientific papers, and wrote more than 10,000 letters. By the time he had reached his 50th birthday he had supervised 147 graduate students, 34 of whom became professors. In 1894 he played a key role in the foundation of the *Deutsche Elektrochemische Gesellschaft* (German Electrochemical Society) which in 1902 became the *Deutsche Bunsen-Gesellschaft für Angewandte Physikalische Chemie* (German Bunsen-Society for Applied Physical Chemistry). With Jacobus Henricus van't Hoff, he also founded the *Zeitschrift für Physikalische Chemie* (Journal of Physical Chemistry), which he co-edited from 1887 until 1906. He was showered with international honours. He was made an honorary member of learned societies in

Norway, Sweden, the Netherlands, Russia, the UK and the USA, and received honorary doctorates from universities in Germany, the UK, and the USA. In 1899 he was made a *Geheimrat* (privy councillor) by the King of Saxony, and in 1909 he was awarded the Nobel Prize for Chemistry for his work on chemical equilibria, chemical reactions, and catalysis.

Despite the acclaim of his peers, Ostwald today is less well-known in the English-speaking world than several of his contemporaries such as Arrhenius, Nernst, and Boltzmann, who were all colleagues of Ostwald at various times. It is therefore fascinating to read Robert Smail Jack's translation of Ostwald's autobiography *Lebenslinien*, originally published in three volumes by Verlag Velhagen and Klasing in 1926. Jack's painstaking efforts shed important light on the scientific and cultural credentials of this influential figure. This new translation also provides some fascinating insights into the social and cultural assumptions of European intellectuals prior to the First World War. In that regard, the text opens a window into a vanished world.

Ostwald wrote several popular books on science, and seems to have anticipated Hawking's famous dictum that every scientific equation halves the number of general readers. As a result, his autobiography is almost equation-free. However, for the specialist reader, this leaves many technical questions unanswered. The text is also in the form of a monologue (dialogue is conspicuously absent) so that the authorial voice dominates the presentation. The result is a retrospective narrative somewhat resembling a diary.

As a religious sceptic, Ostwald thought that every time a writer described a subject in exalted, solemn, touching or uplifting terms then he had probably "abandoned logic and clarity". Possibly so, but by writing in a plain text style he has flattened the emotional landscape of his own life story, and thereby denied the general reader access to some of the highs and lows of his existence. For example, it would have been fascinating to learn more about his career-threatening depression in 1895, or to understand how his complex relationship with Boltzmann developed over time. (Boltzmann committed suicide in 1906.) Ostwald states that he had a relationship of affection and trust with Boltzmann that "brought them often together", yet Ostwald profoundly disagreed with Boltzmann's atomism.

With regard to his family, Ostwald's autobiography is a treasure house for Freudians. He fails to name his father on the opening page, and omits to tell us what it felt like to have three sons enlisted in the military during the First World War. On his deepest feelings he is often evasive. Perhaps his correspondence is more revealing. However that may be, what emerges clearly from the autobiography is that Ostwald alternated between manic phases of energy, ambition, and grandiosity; and depressive phases of lassitude, insomnia, and self-doubt. Indeed, one is tempted to speculate that he suffered from some kind of bipolar disorder, although that would be difficult to prove at this historical distance.

But all was not doom and gloom. Throughout the autobiography, Ostwald provides the reader with amusing anecdotes about his encounters with various scientists and industrialists, and he also shows flashes of a wry sense of humour. Take this, for example (on the matter of theological dissent among the faculty at Leipzig):

"The result of all this for me was that the distance between me and my colleagues from the humanities became clearly greater and they complained even more about my lack of "collegiality". This they understood

as a diligent consideration of their feelings and opinions. Quite naturally they saw no need to consider *my* feelings and opinions for the good reason that they differed from theirs.”

That passage could have sprung from the pages of *Candide*. On other occasions, there are moments of unintended humour, as when Ostwald describes the British method of appointing senior academics:

“In Britain candidates are not selected by a conclave of professors or by the government, rather free positions are advertised and candidates apply themselves. It’s the custom to collect testimonials from as many well-known experts as possible because the appointment committee will often not contain a specialist in the field...”

Can you imagine? *No specialist in the field?* Ostwald was astounded. He’d be even more astounded if he knew that the whole mad process was still intact in many British Universities a century later!

In the art of translation, *domestication* and *foreignization* have long been recognized as opposing tendencies, influencing the degree to which a translator modifies an original piece of work to make it conform to the selected language and culture. As is well known, too much domestication obscures the cultural identity of the original author, while too much foreignization interrupts the smooth flow of the text. A balance must therefore be sought. In the present case, the translator has generally favoured domestication, producing a highly readable text that suppresses some of the profound cultural differences between Ostwald’s world and our own. But the pay-off is an engaging glimpse into the life of an irrepressible scientist operating in the late nineteenth century.

Jack’s translation is 704 pages long. The Herculean task of translating the slightly old-fashioned German into contemporary English must have presented enormous technical difficulties to the translator. So I am happy to report that he has negotiated this minefield with considerable aplomb, producing a text that is both lucid and coherent. The subject matter is always fascinating. Indeed, I was left with a desire to know more about the evolution of thermodynamics in the late nineteenth century, and about Ostwald’s philosophical ideas in the early twentieth century. On the downside, it must be said that some of the diction is occasionally stilted; however this is a mere quibble compared with the total achievement.

As far as the history of science is concerned, Ostwald’s life story fills an important gap. It is well known that the development of steam engines in the early nineteenth century created a wide interest in the thermodynamics of gases at high temperature, which reached its apogee around mid-century. However, what is less well known is the story of how thermodynamic methods came to be applied to liquids at room temperature. Three important questions had to be answered. Firstly, it was unclear how the rates of chemical reactions were related to the concentrations of dissolved substances. Secondly no-one understood what was “really happening” as chemical reactions approached equilibrium. Thirdly, it was unclear which thermodynamic function was acting as the control parameter for the problem. The answer to the first question, now known as the *Law of Mass Action*, was provided by the Norwegian scientists Cato Maximilian Guldberg and Peter Waage in 1864. They showed that the rates of chemical reactions were directly proportional to the products of the concentrations of the reacting species. The American scientist Josiah Willard Gibbs solved the second and third problems shortly after 1870. Gibbs realized that two state functions were needed to interpret the behaviour of condensed phases at constant pressure and temperature. The first of

these is now called the *Enthalpy* H , and the other is now called the *Gibbs energy* G (formerly the free energy). Gibbs established that the change in heat in a system was determined by the change in H , but that the approach to equilibrium was determined by the change in G .

Today, these basic thermodynamic insights are familiar to chemistry undergraduates. But in Victorian times they were virtually unknown, even to the *cognoscenti*. Guldberg and Waage published their results in Norwegian in the little known journal *Forhandling i Videnskabs-selskabet i Christiania* in 1864; while Gibbs published his results in English in the equally obscure *Transactions of the Connecticut Academy of Arts and Sciences* in 1873. Thus, the impact of these masterworks on the progress of chemistry was initially nil. Fortunately, the Dutchman Jacobus Henricus van't Hoff rediscovered the Law of Mass Action nearly twenty years later, and published his results (in French) in 1884 in a memoir entitled *Études de Dynamique Chimique* ("Studies of Dynamic Chemistry"). This came to the attention of Ostwald just as he was focusing on similar ideas. The coincidence led to a friendly correspondence with van't Hoff that culminated in the latter's agreement to become a co-editor on the new *Zeitschrift für Physikalische Chemie*. This journal proved to be the ideal vehicle for the co-editors to promulgate their thermodynamic ideas, and it was an immediate success. During its first year (1887) articles were published by van't Hoff, Ostwald, Arrhenius, Meyer, Raoult, Guldberg, Mendeleev, Thomsen, Le Châtelier, and Planck. Shortly thereafter, in 1892, Ostwald completed a German translation of Gibbs collected works, which further popularized the thermodynamic approach. For the small but expanding circle of "physical chemists" it became an open secret that the Law of Mass Action could be successfully combined with Gibbsian thermodynamics to generate exciting new insights into chemical systems. Four Nobel prizes directly ensued: van't Hoff (1901), Arrhenius (1903), Ostwald (1909), and Nernst (1920). Ostwald received his prize for the application of the Law of Mass Action to weak electrolytes.

A crucial ingredient of Ostwald's success was his awareness that equilibrium systems could not be analysed with high precision unless measuring techniques were available that avoided the perturbation of the equilibrium state. To this end, he developed non-perturbative techniques for the measurement of liquid density, refractive index, polarization state, optical absorbance, electrical conductivity, and electrode potential. Much of his theoretical work was verified by these methods.

For Ostwald, the work of the Swedish scientist Svante Arrhenius was also crucial because of the latter's discovery of electrolytic dissociation. This phenomenon was deeply puzzling to chemists in the 1890s. Since "everyone knew" that opposite charges attracted each other, why didn't anions and cations simply combine? The surprising explanation—that association between anions and cations was actually occurring, but that heat energy was continually dissociating them again—meant that a degree of freedom was missing in all the standard textbook theories of thermodynamics prior to that date. Indeed, due to the equipartition principle, we now know that $kT/2$ of thermal energy was unaccounted for. Incredibly, this evaded direct detection until 1926 when thermal noise in electrolyte solutions was finally observed by another Swede, John Bertrand Johnson (Johnson noise).

At a personal level, Ostwald's lifelong alternation between mania and depression naturally caused him to reflect on their causes. Unlike his contemporary, Sigmund Freud, who thought that depression was a psychological illness caused by unresolved conflicts between the conscious and unconscious parts of the mind, Ostwald thought that depression was a physical illness caused by the depletion of actual mental energy. He called this the doctrine of "energetics" and wrote widely on

the subject. However, his attempts to extend the doctrine of energetics to the whole of the physical sciences (even to the point of denying atomism) drew strong criticism from colleagues at the Lübeck Natural Scientists' Meeting in 1895. Rather than concede the point, however, he began a slow retreat into idealism and mysticism.

After resigning his Chair in 1906, Ostwald embarked on a series of charitable and philosophical ventures, a few of which produced interesting results, but most of which didn't. He was acutely aware that the plethora of European languages was an obstacle to scientific progress, and so he began to advocate *Ido*, a synthetic language derived from Esperanto, as a possible universal second language. Unfortunately, this idea attracted few followers and today is almost forgotten. His involvement with the utopian biologist-philosopher Ernst Haeckel and his "Monist League" was even more unfortunate, leading to personal doubts about the role of natural selection in the process of evolution.

Among his many talents, Ostwald was a skilful amateur painter who developed a strong interest in colour theory. His central idea was to represent all possible colours with code numbers that could be transmitted across space and time. In this regard he anticipated modern developments in information theory:

"I don't need to regret the transience of a flower's beauty because I can transform a large part of that to pure harmony in my pictures. And since I've developed the habit of writing down the codes of the colours I use I always have a sort of score of all of my pictures. This will make it possible, even if time alters the pigments, to call back the original harmonies and thus secure for these harmless but pretty first members of a new artistic epoch an eternal existence for they are now as secure and unchangeable as the great compositions in music or poetry, while the great paintings of times past are inevitably doomed to destruction."

His ideas about fixing colour also attracted the attention of famous artists, including Paul Klee and several members of the *De Stijl* movement, including Piet Mondrian. Despite receiving the Nobel Prize for chemistry, he confidently asserted that "I consider the establishment of the quantitative theory of colours my most important work".

Wilhelm Ostwald died on 4 April 1932. According to Wilder Dwight Bancroft (1867–1953) a former pupil, "Ostwald was absolutely the right man in the right place. He was loved and followed by more people than any chemist of our time." Today, we owe the Editor of the present work, Prof Fritz Scholz, a similar debt of thanks for being "the right man in the right place" in persuading Prof Jack to embark on this translation. In addition to contributing to the textual analysis, Prof Scholz has also supplied a large number of useful footnotes to the text, and furnished an erudite biographical index at the end.

"*Wilhelm Ostwald: The Autobiography*." is an important contribution to the history of physical chemistry. It restores Ostwald to his rightful place as one of the founders of modern electrochemistry. It also sheds light on the extraordinary efflorescence of German science in *fin de siècle* Europe. I would recommend the book to anyone with an interest in the sociology of science or the history of physical chemistry.

/end