

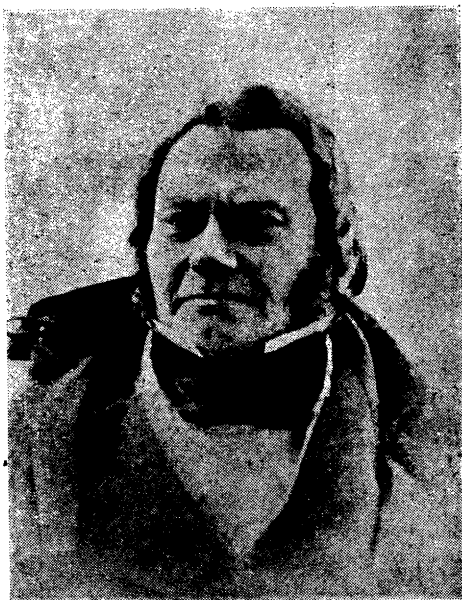
Jöns Jacob Berzelius

A Centenary

August 7th 1948 was the 100th anniversary of the death of Berzelius, the famous Swedish chemist. In his own country, he was a pioneer scientist whose concrete achievements, in a number of different spheres, were very considerable — and it can safely be said that few Swedish scientific workers have achieved a degree of international celebrity equal to his.

On September 20th 1948, some of the institutions to which he once devoted his energies arranged a commemorative meeting in Stockholm Town Hall. Invitations were sent out by *Kungliga Vetenskapsakademien* (The Royal Academy of Science), *Kungliga Karolinska Institutet* (The Royal Caroline Medico-Surgical Institute), *Kungliga Lantbruksakademien* (The Royal Academy of Agriculture) and *Svenska Läkarsällskapet* (The Swedish Medical Association). The opening address was given by Professor Gunnar Holmgren, the President of the Royal Academy of Science, and then followed speeches by Professor Arne Fredga, Professor Hilding Bergstrand, Professor Olof Svanberg and Professor Hugo Theorell, who acted as spokesmen for the organisations mentioned above. A number of scientific societies abroad — and in particular, those to which Berzelius himself had belonged — also sent representatives, who conveyed the greetings of their respective organisations.

This paper has been written with the object of sketching the main features of Berzelius' life and work — with perhaps a stress on certain achievements which were particularly remembered during the Centenary celebrations.



Jöns Jacob Berzelius.
From a daguerreotype taken in Berlin in 1845.

Like many another Swedish scientific worker who achieved fame, Berzelius came from a family of clergymen, originally of peasant stock. The name Berzelius was derived from a farmstead namely Bergsäter in the parish of Motala, where the last of his peasant ancestors lived and laboured. His father, Samuel Berzelius, was a schoolmaster at the *gymnasium* in Linköping. The family sometimes spent a holiday at Väversunda Sörgård in Väversunda Parish, the home of Mrs. Berzelius' parents, and it was here that Jöns Jacob Berzelius was born on



The yard of 'Tyska Bagarns Hus' ('The German Baker's House') in the corner of Nybrogatan and Riddaregatan, Stockholm. During the important period 1809—1818, Berzelius' residence and laboratory were on the first floor of the building on the right.

August 20th 1779. His childhood was however not particularly happy, for at an early age he lost both parents, and he was brought up in the homes of various relatives, under constantly changing and at times unpleasant circumstances. But there is plenty of evidence that at an early stage in his development, Berzelius showed clear signs of a strong-willed and independent character. At the *gymnasium* in Linköping, he became interested in scientific matters and at length decided to break with the family tradition and become a doctor. But his single-minded pursuit of his own special interests led quite naturally to the neglect of certain other studies which seemed to him of less importance — the Hebrew language, for instance. His final certificate, which has often been quoted, mentions his good natural gifts, his bad manners and doubtful future prospects!

In 1786, Berzelius commenced his medical studies at Uppsala University. At first, he derived very little stimulation from the existing text-books on chemistry, but as soon as he had the opportunity of participating in experiments, he 'felt something he had never felt before'. He at once realised that he was irrevocably predestined to work in this field. With great industry and enthusiasm, he went ahead with experiments of various kinds — generally in his own lodgings, but sometimes in the University laboratory, to which he was admitted a century and a half ago: in the autumn of 1798.

Berzelius was an orphan, and had to contend with very great economic difficulties. At the University — just as at the *gymnasium* — he was periodically forced to interrupt his studies in order to earn something as a private tutor. During the summer months, he worked as the doc-

tor's assistant at the Medevi mineral wells, and his very first printed paper was in fact a dissertation *pro exercitio* dealing with an analysis of the water at these wells. This early interest in mineral wells was something which lasted throughout the whole of his life.

At the conclusion of his studies, Berzelius moved to Stockholm with the intention of earning a livelihood as a doctor. All his spare time, however, was devoted to chemical research. He had not been very long in Stockholm before he was engaged as a lecturer at the *Kirurgiska Undervisningsverket* (The Institute of Surgical Education), but it was an appointment which unfortunately carried no salary with it. But it did at any rate lead to Berzelius becoming acquainted with several influential men who soon became his friends — amongst them the erudite iron-master Wilhelm Hisinger, and Johan Gottlieb Gahn, a member of the Board of Mines. In collaboration with Hisinger, Berzelius founded a kind of review entitled *Ahandlingar i Fysik, Kemi och Mineralogi* (Transactions in Physics, Chemistry and Mineralogy). These papers were published in six volumes during 1807—1818, and while Berzelius was the author of the greater part of the contents, it was Hisinger who — at least at the beginning — paid most of the expenses.

In 1805, Berzelius was passed over in connection with the appointment of a professor at the Institute of Surgical Education, but two years later, when the post again became vacant, he obtained it without difficulty. The following year he was elected a member of the Royal Academy of Science, and in 1818 he was made secretary for life. The time had now come when he did not need a review of his own in order to get his works printed. In time, however, he found his duties as secretary so arduous that he took leave of absence from his professorship, and gave it up altogether in 1832. He remained

until his death in the service of the Academy.

Berzelius' first great work dealt with the electrical decomposition of salts — at that time a completely new field of research. He had collaborated with Hisinger in this, and the results were destined to greatly influence Berzelius' theoretical outlook. He had also begun to take an interest in mineralogy, and during his analytical studies in this field, he discovered a new element, namely *cerium*. This was no mere chance, for the mineral in question had already been analysed by Scheele, who however had not found anything worthy of special note. At this time, Berzelius was also very much occupied with the subject now known as physiological chemistry, and it was while working in this field that he discovered sarcolactic acid. He also published two volumes of *Föreläsningar i Djurkemien* (Lectures on Animal Chemistry).

Soon however he became occupied with a problem which absorbed most of the energy of his best years, and which contributed very largely to his future fame, namely his researches into the multiple proportions. At this period in history, the knowledge of chemical compounds was too uncertain to allow of definite conclusions as to the general laws for their composition. This deficiency in human knowledge, arising from the undeveloped state of quantitative analysis, had already been pointed out by Lavoisier. And for some considerable time past, Berthollet and Proust had been discussing the question whether the composition of a compound had to be looked upon as fundamentally constant, or variable. Berzelius, above all things a lover of order and clarity, found this state of affairs rather unsatisfactory — not least from the angle of teaching. He therefore decided to go into the whole complex problem, and at length state as exactly as possible the proportions in which elements unite with each other.

This naturally meant nothing less than the quantitative analysis of thousands of compounds, with constant and strict control of the methods, which usually called for improvement, and sometimes had to be rejected for quite new ones.

The task was gigantic, and took more than ten years: from 1807 to 1818. But the result was that the laws of definite and multiple proportions became settled once for all. It was this work — which found its theoretical background in Dalton's contemporary atomic theory — which provided a firm basis for the further development of chemistry. In the matter of accuracy, Berzelius had moved far in advance of his predecessors, and it has been said that it was he who made chemistry an exact science. Because of his unhesitating and masterly knowledge of facts, Berzelius was able to utter the decisive word in many of the burning controversies of his time, and in consequence he came to be regarded as the greatest living authority in the field of chemistry. It was a position which he held for more than two decades.

During these years he also created our language of chemical symbols. Of course, even before his time, there had been a system of signs and symbols, and they were both venerated and antiquated — an inheritance from the alchemists of the Middle Ages. Berzelius, with his firm grasp of realities, saw that if a system, whatever it might be, was to be of practical use in writing and printing, it had to be founded upon common numbers and letters. Having come to that conclusion, he made a complete break with ancient and hoary traditions. We now know that Berzelius' system of alphabetical symbols proved to be capable of development and adaptation in the general evolution of science, and in our own time it is the indispensable means of formal expression in chemistry.

In the field of mineralogy, the applica-

tion of his new-won knowledge of the laws of chemical compounds enabled Berzelius to create a quite new system — one which contrasted very strongly with the earlier way of looking at these matters, which was natural-historical. Berzelius' system became the norm in later development. During this period of his life, he also performed a number of other tasks in certain special fields — one of them led to his discovery of the element *selenium*.

Journeys to England in 1812, and to England, France and Germany during 1818—19 were of great value to Berzelius. In these countries, he established connections with leading scientists, and both gave and received many fresh impulses. Later still, he often travelled abroad, but by that time the visits had acquired another character. He was now a celebrity, and much of his time was taken up by curious visitors and by all kinds of social functions.

After 1818, when Berzelius was appointed permanent secretary of the Royal Academy of Science, a new period of work began. The affairs of the Academy absorbed much time, but so also did his labours on his great text-book, which at length amounted to ten volumes. There was hardly ever a time when he was not busy with a new edition or translation, or with negotiations with foreign editors. Quite often, the latter had very different ideas to his on questions of precision and accuracy, and they were often made to feel his displeasure. From 1821 onwards he also wrote annual reports on the progress of chemistry, and these became the prototypes of later scientific reference works. Originally, these reports were written only to be read at the annual celebrations of the Academy of Science, but they soon developed into volumes containing 400—700 pages. They were translated into several foreign languages, and were perused by the chemists of every civilised country. Quite naturally, Berzelius' reputation thus became still further enhanced, and it has

been said that he came to be regarded as a kind of 'Supreme Court of Chemistry'.

But in spite of all these far-reaching activities, Berzelius continued with practical experiments until far into the 1840's. He made very important investigations in the realm of sulpho and seleno salts and fluoro and chloro salts, and in the chemistry of tellurium and the platinum metals. He also investigated various groups of organic compounds. For instance: he discovered pyruvic acid and stated that racemic acid and tartaric acid were of identical composition. But in many instances, his work in organic chemistry had rather the character of a preliminary survey of the field. He also continued with mineral analyses, and in doing so he discovered the element *thorium*. He also revised and corrected earlier determinations of atomic weights and he carried out numerous controlling investigations in connection with his annual reports, or for the purpose of checking and supplementing the work of others.

Berzelius received both Swedish and foreign disciples into his laboratory — only a few at a time, however. It was there that Arfwedson discovered *lithium* and Sefström discovered *vanadium*. But in both cases, it is probable that Berzelius was the actual discoverer, though he allowed his disciples to take the credit. Amongst the foreigners who worked with him in this way we note, first and foremost, the Germans Mitscherlich, Rose, Magnus and Wöhler — and it was the last-named whose personal relations with Berzelius were closest.

We may say that Berzelius sought to survey, put in order and systematize the whole of his field of science. As a young man, he had penetrated very deeply into Lavoisier's way of thinking, and his subsequent development was determined by two important experiences, namely the definite proportions and the electrolytic phenomena. The former constituted a

foundation that could be built upon — the latter did not. The primitive electrical science of the early 19th century could not solve the problem of chemical affinity. From his comparatively simple starting points, Berzelius could not in spite of much ingenious toil master the tangled puzzles of organic chemistry, and the general development of science travelled along other paths. Hence it happened that towards the end of his life, he found himself strongly opposed to certain of the younger scientists who, searching for new ways and viewpoints, suffered from the pressure of his authority. But it is only in our own time that the electrical nature of chemical affinity has become more clear.

Berzelius' outstanding characteristic was a respect for facts, and he was averse to all speculation with no solid base. It is certain that this personal quality contributed in no small measure to his ultimate success, for he began his chemical researches at a time when that science sorely needed, above all things, established facts and reliable data. But later in Berzelius' life, all this hardened into a somewhat conservative outlook, and he became very reluctant to alter an opinion unless he had very certain proofs that it was inaccurate. Thus it was that rather late in the day, he agreed to recognise the halogenes as elements. His criticisms, however, were very rarely no more than negative, and as soon as he had convinced himself of the accuracy of an observation, he was eager to give it a place in his system, to generalise upon it, and to search for a suitable terminology. And in this way he coined the terms *isomerism* and *catalysis*.

We ourselves can see Berzelius' personal character revealed in a very clear light, for his was a most open and frank nature. He wrote a clear, easy and fluent style, and his correspondence is very extensive. Further, we have much information from people who were closely acquainted with him. It is said that in his younger days,

he was inclined to be a little 'choleric', and given to 'holding on to his rights', but in later life he is described as having an equable temperament: amiable, benevolent and with a great sense of humour. It was a sometimes rather drastic humour, and his letters reveal a rich fund of it. In his personal relations — as for instance in any home circle — he made a most profound impression on everybody, and it was very easy for him to acquire both friends and influence.

Additional activities were in the realm of public affairs — especially those relating to higher education and health. It is clear that he was a man of very great practical ability — a faculty that revealed itself not least in his energetic and far-seeing management of the affairs of the Academy. But he had no flair for money-making by means of the practical application of his scientific knowledge, and his attempts in that direction brought him little else but trouble. His discovery of *selenium* was however the outcome of an industrial commitment. As a professor, he worked energetically for the development of the Institute of Surgical Education (after 1810 known as *Kungliga Karolinska Institutet*) into a complete medical school, and in doing so he met with strong opposition from the old universities — often the objects of his biting sarcasm.

From the time of its foundation, Berzelius was a member of the Royal Academy of Agriculture, and for several decades he was president of the Scientific Department of that institution. He was also one of the founders of the Swedish Medical Association, and as a member of it played an important rôle.

Because of his absorption in his numerous tasks, Berzelius had very little time even to think of marriage and family life, but at the age of 56, however, he married the daughter of one of his closest friends. And on his wedding day, King Charles XIV. John conferred upon him the title of baron. As the years passed, Berzelius acquired still further honours, and he was made a member of more than 80 academies and scientific societies in different parts of the world.

As one becomes more familiar with Berzelius' character, his most imposing features are perhaps his encyclopaedic mind and his enormous capacity for work. Undaunted, he undertook tasks which might well have been thought above the capacity of any one man. But with never-failing persistence, he tackled them and solved them. And although he was very careful about correctness of detail, it was always the main outline of a problem which aroused his interest. He did not care for special hypotheses of limited range, and he never allowed himself to move within the narrow groove of one special and particular study. As a man and as a scientist, Berzelius had the qualities of solidity and honesty, and his scientific motto was in fact: 'Clarity and Truth'.

The chief work on Berzelius (published only in Swedish) is H. G. Söderbaum's *Jac. Berzelius I—III* (Uppsala 1929—31). His 'Autobiographical notes' have been published in Swedish (Stockholm 1901), English (Baltimore 1934) and German (Leipzig 1903). Six volumes of letters have been published by H. G. Söderbaum (Uppsala 1912—32). Berzelius' correspondence with Liebig, Wöhler and Magnus was published in Germany.

Arne Fredga