MISCELLANEOUS.

ROBERT WILLIAM BUNSEN.

(1811–1899.)

The recent *Short History of the Progress of Scientific Chemistry in Our Own Times*,[1] by Dr. William A. Tilden, F. R. S., Professor of Chemistry in the Royal College of Science, London, which gives in concise compass a historical survey of that succession of wonderful events which led up to our present knowledge of chemistry, has suggested to us to offer to our readers a portraiture of one of the central and dominating figures of that development, one of the grandest that have adorned the annals of research, and one who by the simplicity and enormous compass of his work occupies a place by the side of Galileo and Faraday in the pantheon of Science,—Robert William Bunsen. The elementary student and reader may follow admirably in Dr. Tilden's little book the history of the development of theoretical chemistry, but of the numerous fascinating personalities of that development naturally nothing could be said. It remains, therefore, for the reader to seek this material in other places.

Robert William Bunsen, joint discoverer of spectrum analysis, was born at Göttingen, March 31st, 1811, and died at Heidelberg in 1899 His long life spanned thus the chemical achievements of the century, forming a magnificent arch that connected the great inquirers of the past with the workers of to-day. Berzelius was his most intimate friend ; Gay-Lussac his instructor ; Dumas, Liebig, Wöhler, Mitscherlich, Weber, Magnus,—all were his contemporaries and intimates. Living to the great age of eighty-eight, he was destined to witness the rise and death of most of the century's and his country's greatest inquirers,—many of whom had been his colleagues and pupils : Kirchhoff, Helmholtz, Kopp, Hofmann, Strecker, Kolbe, Kekulé, Pebal, Lothar Meyer, and lastly Victor Meyer, his successor in the chair of chemistry at Heidelberg. Outliving them all, there in his later years, says Sir Henry Roscoe, "Bunsen stood alone in his glory, like some strong oak in the forest which still holds firm root unmoved by the tempests which have smitten both young and old around it."

Twenty years ago, in the columns of *Nature*, Sir Henry Roscoe, one of Bunsen's most distinguished pupils and most intimate friends, gave this estimate of Bunsen's scientific work :

"The value of a life devoted to original scientific work is measured by the new paths and new fields which such work opens out. In this respect the labors of Robert William Bunsen stand second to those of no chemist of his time. Out-

[1] Longmans, Green, & Co., London, New York and Bombay. 1899. Pages, x, 276.

wardly, the existence of such a man, attached, as Bunsen had been from the first, exclusively to his science, seems to glide silently on without causes for excitement or stirring incident. His inward life however is, on the contrary, full of interests and of incidents of even a striking and exciting kind. The discovery of a fact which overthrows or remodels our ideas on a whole branch of science; the experimental proof of a general law hitherto unrecognised; the employment of a new and happy combination of known facts to effect an invention of general applicability and utility; these are the peaceful victories of the man of science which may well be thought to outweigh the high-sounding achievements of the more public professions."

Last year, in March, six months after his great master's death, Sir Henry Roscoe delivered a Bunsen memorial lecture before the Chemical Society of London.[1] This lecture teems with personal recollections, and gives us so vivid and rare a picture of the man, as he worked in his laboratory, lectured to his students, and enjoyed the simple yet refined intercourse of his friends, that we shall quote from it at length, after we have given some of the meagrest data of Bunsen's life.

Bunsen was successively teacher and professor in Göttingen, Cassel, Marburg, Breslau, and Heidelberg (1852–1889). His first classical research was one on the cacodyl compounds, which placed him in the front rank of experimentalists, and by which he incidentally lost the sight of his right eye, was nearly poisoned, and lay days between life and death. His next research was the investigation of the composition of the gases of iron furnaces for German and English manufacturers, of the modes of measuring gaseous volumes, and of the methods for separating the several gases. The results have been characterised as "a model of the application of the methods of scientific investigation to the elucidation of industrial problems," and Bunsen's direct proposals are estimated to have led to economies that must be "reckoned by millions rather than thousands of pounds." Bunsen collected the theoretical results of those researches in his work *Gasometric Methods* (the only book he ever published), which is epoch-making, and covers a field too vast to be even epitomised here.

One of Bunsen's best-known discoveries is the carbon-zinc battery which bears his name, and which rendered possible the more perfect electrolytic preparation of metals, the preparation of the metals of the alkaline earths, the electrolysis of acetic and valeric acids, etc., etc.

We must pass over a host of other important investigations, both chemical and physical, to the researches on spectrum analysis, which constitute one of the crowning glories of the nineteenth century. Bunsen writes (1859) to Roscoe of his and Kirchhoff's work as follows: "At the moment I am engaged in a research with Kirchhoff which gives us sleepless nights. Kirchhoff has made a most beautiful and most unexpected discovery; he has found out the cause of the dark lines in the solar spectrum, and has been able both to strengthen these lines artificially in the solar spectrum and to cause their appearance in a continuous spectrum of a flame, their positions being identical with those of the Fraunhofer lines. Thus the way is pointed out by which the material composition of the sun and fixed stars can be ascertained with the same degree of certainty as we can ascertain by means of our reagents the presence of SO_3 and Cl. By this method, too, the composition of terrestrial matter can be ascertained and the component parts distinguished with as great ease and delicacy as is the case with the matter contained in the sun. Thus I have been able to detect lithium in twenty grams of sea water. For the

[1] *Transactions*, vol. 77, 513–554. Reprinted in the *Smithsonian Report* for 1899.

detection of many substances this method is to be preferred to any of our previously known processes. Thus, if you have a mixture of Li, Ka, Na, Ba, Sr, Ca, all you need to do is to bring a milligram of the mixture in our apparatus in order to be able to ascertain the presence of all the above substances by mere observation. Some of these reactions are wonderfully delicate. Thus it is possible to detect five one-thousandths of a miligram of lithium with the greatest ease and certainty, and I have discovered the presence of this metal in almost every sample of potashes."

Then followed the discoveries as caesium (1860) and rubidium (1861), leading to the separation by others of thallium (1861), indium (1863), germanium (1886), gallium (1875), scandium (1879), etc.

Celebrated, too, were Bunsen's researches on chemical geology, especially those concerning the volcanic phenomena of Iceland; on the metals of the platinum group; etc., etc. Of his famous burner, we will hear later. We now revert to Sir Henry Roscoe's recollections.

First let us take this picture of the master working in the laboratory: "When he first came to Heidelberg, in the summer of 1852, Bunsen found himself installed in Gmelin's old laboratory. This was situated in the buildings of an ancient monastery, and there we all worked. It was roomy enough; the old refectory was the main laboratory; the chapel was divided into two; one half became the lecture room and the other a storehouse and museum. Soon the number of students increased and further extensions were needed, so the cloisters were inclosed by windows and working benches placed below them. Beneath the stone floor at our feet slept the dead monks, and on their tombstones we threw our waste precipitates! There was no gas in Heidelberg in those days, nor any town's water supply. We worked with Berzelius's spirit lamps, made our combustions with charcoal, boiled down our waters from our silicate analyses in large glass globes over charcoal fires, and went for water to the pump in the yard. Nevertheless, with all these so-called drawbacks, we were able to work easily and accurately. To work with Bunsen was a real pleasure. Entirely devoted to his students, as they were to him, he spent all day in the laboratory, showing them with his own hands how best to carry out the various operations in which they were engaged. You would find him with one man showing the new method of washing precipitates, so as to save time and labor, or with another working out a calibration table of a eudiometer, or with a third pointing out that the ordinary method of separating iron from aluminum is unsatisfactory and carrying out a more perfect process before his eyes. Often you would find him seated at the table blowpipe—the flame in those days was fed with oil—making some new piece of glass apparatus, for he was an expert glass blower, and enjoyed showing the men how to seal platinum wires into the eudiometers, or to blow bulb tubes for his iodometric analyses. Maxwell Simpson, who worked with Bunsen in the fifties, tells me that one day he saw Bunsen blow a complicated piece of glass apparatus for a pupil, who quickly broke it; Bunsen then made him a second, which at once met with a similar fate; without a murmur Bunsen again sat down to the blowpipe and for the third time presented the student (who we will trust looked ashamed of himself) with the perfect apparatus. Then he would spend half the morning in the gas-analysis room, going through all the detailed manipulation of the exact measurement of gaseous volumes, and showing a couple of men how to estimate the various constituents of a sample of coal gas, and pointing out the methods of calculating the results, and then leaving them to repeat the processes from beginning to end for themselves.

"His manipulative ability was remarkable; his hands, though large and powerful, were supple and dexterous. He was amusingly proud of having a large thumb, by means of which he was able to close the open end of a long eudiometer filled with mercury and immerse it in the mercury bath without the least bubble of air, a feat which those endowed with smaller digits were unable to accomplish. Then he had a very salamanderlike power of handling hot glass tubes, and often at the blowpipe have I smelt burnt Bunsen, and seen his fingers smoke! Then he would quickly reduce their temperature by pressing the lobe of his right ear between his heated thumb and forefinger, turning his head to one with a smile as the 'agony abated,' while it used to be a joke among the students that the master never needed a pincette to take off the lid from a hot porcelain crucible.

"Accuracy of work was the first essential with him; most of us learned for the first time what this meant. Six weeks' work was spent on a single silicate analysis, but most of us contrived to keep two such analyses going at once, while an analysis of coal gas occupied a week or ten days. Not that he was averse to quick processes; indeed, many of his own investigations contain novel proposals for shortening chemical methods, but this was never done at the expense of accuracy.

"After having learned his methods of quantitative work, of silicate analysis, for example, and after having gone through a course of gas analysis, those of us who had already been more or less trained elsewhere were set upon some original investigation. Lothar Meyer, who worked at the next bench to myself, being a medical student, was set to pump out and analyse the blood gases; Pauli and Carius worked on gas absorption, employing for this purpose Bunsen's recently invented absorptiometer; Russell was set to work out a new method of sulphur determination in organic bodies; Matthiessen was put on to the electrolytic preparation of calcium and strontium; Schischkoff analysed the gaseous products of gunpowder fired under varying conditions; Landolt had to find out the composition of the gases in various portions of a flame, and I worked by myself in one of the monk's cells upstairs on the solubility in water of chlorine when mixed with hydrogen and carbonic acid, the object being to ascertain whether this gas obeys the law of Dalton and Henry.

"These are only some of the investigations on a variety of subjects carried on in the old monastery by Bunsen's pupils under his supervision, and they indicate only a tithe of his activity, for at the same time he was engaged in investigations of his own. He always had two or three on hand at once."

Here is the story of the invention of the famous Bunsen burner and the Bunsen battery: "Some short time before the opening of the new laboratory the town of Heidelberg was for the first time lighted with gas, and Bunsen had to consider what kind of gas-burner he would use for laboratory purposes. Returning from my Easter vacation in London, I brought back with me an Argand burner with copper chimney and wire-gauze top, which was the form commonly used in English laboratories at that time for working with a smokeless flame. This arrangement did not please Bunsen in the very least. The flame was flickering; it was too large, and the gas was so much diluted with air that the flame temperature was greatly depressed. He would make a burner in which the mixture of gas and air would burn at the top of the tube without any gauze whatsoever, giving a steady, small, and hot, nonluminous flame under conditions such that it not only would burn without striking down when the gas supply was turned on full, but also when the supply was diminished until only a minute flame was left. This was a difficult, some thought it an impossible, problem to solve, but after many fruitless attempts and many tedious trials he succeeded, and the Bunsen burner came to light. So general, indeed so universal, has the use of this become that its name and value must be known to and appreciated by millions of the human race. Yet how few of these have any further ideas connected with the name of its author!

"Another discovery which early brought him prominently before the public was that of the Bunsen, or as he preferred to call it, the carbon-zinc battery. The manufacture of either the battery or the burner might, had the inventor wished, have been so guarded as to bring in a large fortune. But Bunsen had no monetary ambition, although he fully appreciated the importance of applied science; and this is a fine trait in his character. He not only disliked anything savoring of money-making out of pure science, but he could not understand how a man professing to follow science could allow his attention to be thus diverted from pure research. 'There are two distinct classes of men,' he used to say; 'first, those who work at enlarging the boundaries of knowledge, and, secondly, those who apply that knowledge to useful ends.' Bunsen chose the first—perhaps one may say the higher—part, and the notion of making money out of his discoveries, or of patenting any of them, never entered into his head. As illustrating this habit of mind, I remember that once we were talking about a former pupil of his, of whose scientific ability he entertained a high opinion. 'Do you know,' he remarked to me, 'I can not make that man out. He has certainly much scientific talent, and yet he thinks of nothing but money-making, and I am told that he has already amassed a large fortune. Is it not a singular case?' To which I replied that I did not find it so very remarkable."

When the new laboratory was built, the research-work which Bunsen had initiated and which his afterwards famous disciples carried on, was tremendous. But, in addition, "there were the beginners, to the number of sixty or seventy, all of whom were looked after by the professor, and with some of whom he would spend hours showing them how to detect traces of metals by aid of the 'flame reactions,' or how to estimate the percentage of dioxide in pyrolusite by his iodometric method. So from Bunsen all who had eyes to see and ears to hear might learn the important lesson that to found or to carry on successfully a school of chemistry the professor must work with and alongside of the pupil, and that for him to delegate that duty to an assistant. however able, is a grave error.

"How, it may be asked, could a man who thus devoted himself to supervising the work of others in the laboratory—and who, besides, had a lecture to deliver every day, and much university business to transact—how could he possibly find time to carry out experimental work of his own? For it is to be noted that Bunsen never kept an assistant to work at his researches, and unless co-operating with some one else, did all the new experimental work with his own hands.

"It is true that in certain instances he incorporated the results of analyses made by a student whom he could trust, into his own memoirs; notably this was the case with the silicate analyses which he used in his chemico-geological papers, and with many of the examples given in illustration of some of his new analytical methods. Then, spending the whole day in the laboratory, he was often able to find a spare hour to devote to his own work of devising and testing some new form of apparatus, of separating some of the rare earth metals, or of determining the crystalline form of a series of salts.

"Again the editing of the research, and the calculations, often complicated, which that involved, were carried on in the early morning hours. When, for four summers after the year 1857 I spent my vacations working at Heidelberg, I lived in his house, and although I rose betimes, I always found him at his desk, having begun work often before dawn.

"Then, although he frequently travelled during the vacations at Easter and in the autumn, often, I am glad to remember, with myself as companion, he generally returned after a short absence to continue an unfinished, or to commence some new, research, and during these quiet days much work was done by both of us."

Then follows a description of Bunsen as a lecturer: "Bunsen lectured on general chemistry every morning in the week from 8 to 9 in the summer, and from 9 to 10 in the winter semester. The lectures were interesting and instructive, not from any striving after oratorical effect, or by any display of 'firework' experiments, but from the originality of both matter and illustration. His exposition was clear, and his delivery easy, and every point upon which he touched was treated in an original fashion; no book, of course, was used or referred to; indeed, he avoided much consultation of handbooks, the only two which I have seen him occasionally turn to for the purpose of looking up some facts about which he had doubts were Gmelin and Roscoe and Schorlemmer. When occasionally one of the practicanten consulted him about a passage in some manual which appeared defective, he would laughingly remark that most of what is written in books is wrong.

"The illustrative lecture experiments, which he invariably performed himself, were generally made on a small scale, were often new, always strictly relevant to the matter in hand, and never introduced for mere sensational effect. He paid much attention to these experiments, and after the table had been set in order for the particular lecture by the assistant, he would regularly spend half an hour, sometimes an hour, in convincing himself that all was in readiness and in rehearsing any experiment about the success of which he was not perfectly certain.

"He used few notes, but it was his habit to write up any numerical data in small figures on the blackboard, and to refresh his memory with these when needed. When I attended the lectures in the early fifties, Bunsen used the notation and nomenclature of Berzelius, writing water $\dot{H}$, and alumina $\dddot{Al}_2$. Later on, he still employed the dualistic notation, writing $KOSO_3$, $HOSO_3$, for K_2SO_4 and H_2SO_4; indeed, I believe that he never adopted our modern formulæ or used Cannizzaro's atomic weights, although his determination of the atomic heat of indium and his work on cæsium and rubidium were amongst the most important contributions towards the settlement of those weights.

"Bunsen did not enlarge in his lectures on theoretical questions; indeed, to discuss points of theory was not his habit, and not much to his liking. His mind was eminently practical; he often used to say that one chemical fact properly established was worth more than all the theories one could invent. And yet he did much to establish the evidence upon which our modern theories rest."

It is interesting to note that Bunsen's constitution, having stood him in stead for eighty-eight years, was vigorous: "It carried him fairly well through a long life; still, continued exposure to the fumes and vitiated air of the laboratory induced bronchial troubles, from which in later life he suffered considerably. Beyond one sharp attack of peritonitis when travelling with Pagenstecher in the Balearic Islands, I do not think he ever had a serious illness. His habits were frugal, the only extravagance in which he indulged being his cigars. Of these he consumed a fairly large number, always having one or a part of one in his mouth; but as he generally allowed it to go out many times before he finished smoking it, the time it lasted was much above that of the average smoker."

At last the end came: "In 1889 Bunsen retired from active university life, resigning his professorship, and therefore his official residence, and retiring to a pretty little villa in Bunsenstrasse, which he had purchased, where he spent the remainder of his days in quiet repose. His chief relaxation and enjoyment throughout his life in Heidelberg was to wander with Kirchhoff or Helmholtz or some other of his intimate friends through the chestnut woods which cover the hills at the foot of which the town lies. As the infirmities of age increased and his walking powers diminished, he was obliged to take to driving through the woods along the charming roads which intersect the hills in all directions. Writing became a difficulty, and in his latter days the news of him came to me through our mutual friends Quincke and Königsberger.

"Almost up to the last Bunsen continued to take a vivid interest in the progress of scientific discovery, and, though suffering from pain and weakness, ever preserved the equanimity which was one of his lifelong characteristics. Three days before his death, so Quincke writes to me, he lay in a peaceful slumber, his countenance exhibiting the fine intellectual expression of his best and brightest days. Thus passed away, full of days, and full of honors, a man equally beloved for his great qualities of heart as he is honored for those of his fertile brain, the memory of whom will always remain green among all who were fortunate enough to number him among their friends." μ.

DR. LEWIS G. JANES.

OBITUARY NOTICE.

It was with the profoundest regret that we learned of the death of Dr. Lewis G. Janes, lecturer and expositor of science, ethics, and religion, at Greenacre, Maine, on September 5th last. Dr. Janes was very prominent in the free religious and ethical circles of this country, and was an early contributor to *The Open Court*. He did a large amount of historical, sociological, and ethical writing, also, for other magazines (*Westminster Review*, *Popular Scientific Monthly*, *Unitarian Review*, *Boston Index*, etc.) and was an indefatigable lecturer.

Dr. Janes, on his father's side was a direct descendant in the seventh generation from Geo. William Bradford of Plymouth Colony; and, on his mother's side, also in the seventh generation, a descendant from Peregrine White, born on the Mayflower in Massachusetts Bay. "He was born," says a writer in the *Boston Evening Transcript* of September 9th, "in the city of Providence fifty-seven years ago, his parents being people of broad and liberal views in religion and all subjects affecting the well-being of society. What is more, they were enthusiastic Abolitionists, and . . . great friends of Frederick Douglass. He was a pupil in the grammar and high schools, from the latter of which he graduated. . . . Early in life, being of studious habits, Dr. Janes mapped out for himself a literary career, and into such a career he gradually settled. Having become a resident in the city of Brooklyn, he identified himself with Rev. J. W. Chadwick's church, and in the Sunday school there he took charge of an adult Bible class, which became so large and was attended by so many earnest seekers after truth that the class grew into the famous and successful Brooklyn Ethical Culture Association. Dr. Janes became president and his position afforded him splendid opportunities for preparing and presenting many addresses bearing on the religious, philosophical, sociological, and political life of the community. He was always a close and fearless student of the theory of evolution, so that when, during the holding of the Parliament of Re-