Henry Enfield Roscoe

The Life & Experiences

of Sir Henry Enfield Roscoe

Selected Chapters

Chapter III. **"Heidelberg du feine"**
Chapter IV. **"Bunseniana" and Heidelberg Friends**

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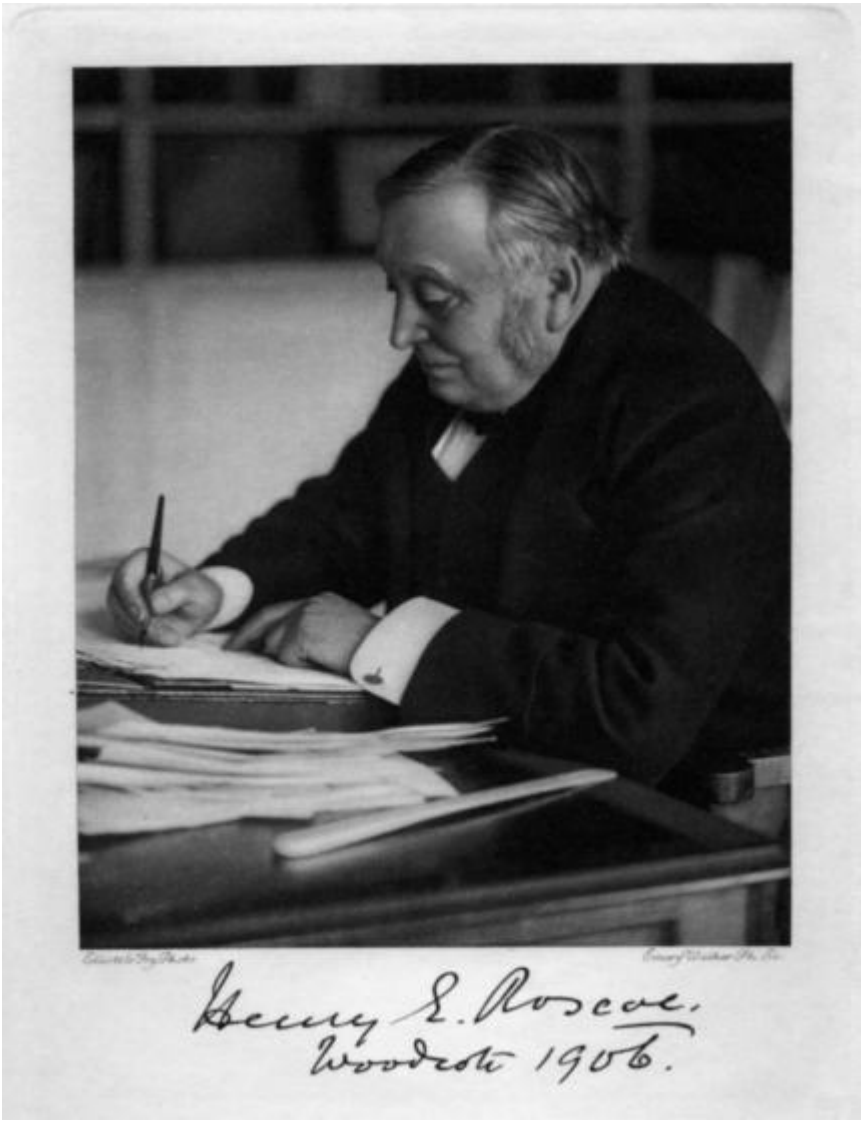

Henry E. Roscoe, 1906

THE LIFE & EXPERIENCES OF SIR HENRY ENFIELD ROSCOE, D.C.L., LL.D., F.R.S. WRITTEN BY HIMSELF . . .

"What is the use of health, of life, if not to do some work therewith?"

CARLYLE, "Sartor Resartus."

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CHAPTER III

"HEIDELBERG DU FEINE"

Heidelberg—Bunsen—Fellow-students—Heidelberg Doctorate—Photo-chemical Researches—German University Life.

HAVING taken the degree of Bachelor of Arts in the University of London in 1853, I was able to give my whole attention to the study of the science to which I had determined to devote my life. In the course of my chemical work I had naturally become acquainted with Bunsen's fame as a teacher as well as with many of his researches, and I had a great desire to work under him. I therefore persuaded my mother, who was nothing loth, to accompany my sister and myself to Heidelberg, to which university Bunsen had just been called from Breslau.

The mass of British tourists who pass through Heidelberg each summer to enjoy the charming scenery of that delightful spot know little and perhaps care less about that which really marks this town as one of the most illustrious and ancient seats of learning in the world. They are satisfied to stroll round the ruins of the Heidelberg Schloss, and to wonder at the Gesprengte Turm outside, and at the Grosse Fass inside the Castle. The very existence of the far-famed Ruperto-Carola is to most of these travellers unknown, and it is only if by chance they meet some corps students in gala costume, or hear of some more than

usually serious duel, that it occurs to them that there exists in the town a curious kind of institution called a German university.

Several friends joined us for the tour up the Rhine. We left by the "Baron Osy" one Sunday in August 1853, and on the following morning arrived at Antwerp, a city which from its picturesqueness and individuality was then one of the best that could be chosen for the first visit of an Englishman to the Continent.

We journeyed by boat slowly up the Rhine, stopping at the places which were still old-fashioned, our only alternative to the steamer being the lumbering diligence.

Arrived at Heidelberg and having presented our letters of introduction to Professor von Mohl and others, our first object was to secure a domicile. This we obtained in the house of a typical old South-German woman, Frau Frisch, near the Karlsthor, and here we established ourselves, my mother, my sister, myself, and my cousin Enfield Dowson, a boy of about sixteen, who had come with us to go to school in Heidelberg and learn German. Everything was new to us, and we all entered into the spirit of the thing.

I had time to get up my German before the lectures began, and with the help of an old pedagogue and that of our maid Gretchen, and by attending service in the German church on Sundays (a practice which I did not continue long), I got my ear pretty well accustomed to the language and was able to make myself understood.

The Mohls were a charming family, and the professor a polished man of the world, totally unlike the usual English idea of a German professor. His family consisted of his wife, two daughters, and two sons, with all of whom we became intimate. He had three brothers—Hugo von Mohl, the celebrated professor

of botany in Tübingen; Maurice, who was high in the Würtemberg diplomatic service; and Jules, the Parisian Orientalist of world-wide fame, and the husband of the equally well known Madame Mohl. In fact the whole family was "ein eroberendes Geschlecht." The eldest daughter of the Heidelberg professor married a distinguished Austrian statesman, von Schmidt, and Anna, the other daughter, became the second wife of my friend Helmholtz, to whom I shall have occasion to refer later. I shall never forget the kindness and hospitality which we received from the Mohl family. We used to take tea with them, for, unlike many of the Germans of the time, they always drank tea in the evening, and I remember on one of my first visits I addressed Frau von Mohl as "Madame," and Anna at once informed me that I must never say this to her mother, as that was how they spoke to the market-women; I must address her as "Gnädige Frau."

The Mohls used to give dances in the *salon* of their house in the Hauptstrasse, and I was very much surprised at one of my first balls to see the belle of the room take a little comb out of her pocket and arrange her hair in front of one of the ball-room mirrors; but to this I got afterwards quite accustomed. They occupied the first *étage* at an oil merchant's, and I remember an amusing story about this man, who was disputing with one of his brother burghers as to which was the heavier, a cask of oil or a cask of water, and insisted that the oil cask weighed more than the water cask, to which his friend replied: "Why, don't you know that oil swims on the top of water, and that therefore it must be lighter?" "That is just it," said he; "the oil is so heavy that it pushes the water down."

Shortly after Bunsen had returned from his autumnal travels, Professor von Mohl kindly introduced me to the great chemist. I shall never forget my first sight of him—the man who afterwards became one of my dearest friends, and to whom I owe more than I can tell. He lived at that time in some rooms on the Anlage, for he was and always remained a bachelor, and was then at the height of his mental and physical powers. He stood fully six feet high, his manner was simple yet dignified, and his expression one of rare intelligence and great kindness. This first impression of his bearing and character only became stronger as my knowledge of him increased, and the feelings of respect and affection with which I regarded him were those of all with whom he came in contact. His singular amiability was not a sign of weakness but of strength of character. His modesty was natural and in no degree assumed. In his lectures, when giving an account of some discovery he had made, or some new apparatus or method of work which he had instigated, I never heard him mention himself. It was always "man hat dies gesunden," or "es hat sich so herausgestellt." In his old age, and looking back on his life-work, he writes me that he "feels as keenly as ever how modest and contemptibly small is the amount which I have added to the building of Science." And yet the contributions of this man have been equalled by few.

Bunsen succeeded Gmelin, whose great book was for many years what may be called the Chemist's Bible, and had been translated into English under the auspices of the Cavendish Society. The laboratory was a quaint one; it had been an old monastery. The high-roofed refectory had been fitted up with working benches, whilst the chapel became the store-room. The

increasing number of students, however, made it necessary to enclose the cloisters with glass windows, in front of which a series of working benches were arranged. One of these was given to me, and on one side worked Lothar Meyer, and on the other side Pauli, whilst Russell and Hermann, and Atkinson and Meidinger, occupied neighbouring places. Of course we had neither water nor gas laid on. We used Berzelius spirit-lamps, drew our water from the pump, and threw down our useless precipitates on the tomb-stones of the old monks under our feet; all our combustions were of course made with charcoal, and the evaporation of the wash-waters of our analyses was carried out over charcoal fires.

Bunsen soon set me at quantitative work, and I first learnt from him what accuracy of manipulation meant. His system of silicate analysis was carried on by almost all the men (each analysis occupying six weeks), and he used the results for verifying the law with regard to the acid and basic silicates, which he first brought forward in his celebrated memoirs on the composition of Icelandic rocks. As soon as I had obtained the requisite amount of facility for work of this kind, he put me through a complete course of gas analysis, for which he was specially celebrated, and thus I learnt a number of manipulative details as well as exact methods of measuring and estimating gas volumes.

Having in these and other ways put me on my mettle, and having thus gained confidence in my powers of accurate and trustworthy manipulation, the Master set me on to original work. The outcome of these, my early flights into unknown regions, were not of striking import, but they served as an introduction to better things to come.

Bunsen was not only a great investigator but a stimulating and inspiring teacher. His lectures were, like everything he touched, marked by originality of treatment. He did not attempt to catch the attention of his audience by brilliancy of style or by "firework" experiments; but his exposition was luminous, and his experiments, always made with his own hands, were exactly illustrative of the matter under discussion. As soon as the lecture was over he went into his laboratory. There he would find about a hundred men waiting for his assistance and advice, and there he spent the whole of his day, superintending the practical work of his students.

To work with Bunsen was a real pleasure. He did not confine his attention merely to those who were engaged in original inquiry; even the beginner had the benefit of seeing how the Master worked, and some of the most elementary operations in analytical chemistry were performed by him at the bench of the pupil. Thus, he taught us not only by precept but by example, and from him we learnt what accurate work meant. We saw how to eliminate errors of experimentation, and to find out where more errors lay. It was this complete devotion to his science and to his students that drew men from all quarters of the globe to study under him; no one who cared to benefit from his teaching was ever sent empty away, and all who had worked in the Heidelberg laboratory looked back upon the time spent there as one of the most fruitful periods of their lives.

It was, however, specially to the advanced students engaged in investigation that Bunsen's heart went out, and to them he gave unstintedly his time and labour. For to these men he knew the future of the science belonged, and that it was they who would hand down,

burning more or less brilliantly, the torch of progress. There would be, perhaps, twenty men thus engaged, not, as in many laboratories, all working on closely cognate subjects, but each one on matters differing widely, and therefore requiring much greater grasp and attention on the part of the teacher, to whom the initiation and often the general conduct of the research was due. This constant presence of the master, this participation by him in the work of the pupils both young and old, bore in on the minds of all the lesson that it is the personal and daily contact with the leader which creates a successful school; and that whilst fine buildings and well-equipped laboratories are good things in their way, they are as tinsel and dross, unless accompanied by the devotion and collaboraton of the teacher.

How, it may well be asked, could Bunsen, thus devoted to supervising the work of others in the laboratory, who had to deliver a lecture every day, and had much perfunctory university business to transact as well—how could he possibly find time to carry on laborious experimental investigations of his own? for he never kept an assistant, as many do, to work at his researches for him, but did all the experimental work with his own deft hands. Well, it is always the busy man who has most time for work—or at least who does most—and so it was with Bunsen. Spending the whole day in the laboratory, he was often able to spare an hour or two to devote to his own work, either of devising and testing some new form of apparatus, of separating the rare earth metals, or of preparing and determining the crystalline form of a series of salts. Then he was an early riser, and when I lived with him, I know that it was his habit to rise often before dawn in the summer, to complete an experi-

ment or to edit a research. And then much original work was done in his vacations.

Before his appointment Bunsen had stipulated with the Government of the Grand-Duchy of Baden that new laboratories should be built for him, and these were shortly completed, and the old monastery pulled down to make way for a new physical institute and a zoological museum.

Up to 1853 Heidelberg had not been supplied with gas, and it was quite an event for the good Heidelbergers when the gas-lamps were first lighted in the town. Of course, Bunsen at once saw the advantage of having gas for heating purposes in the laboratory, and I brought from London a sample of the gas-lamp which we had been using in University College. This consisted of an ordinary argand burner, above which was a cylindrical copper chimney, and on the top of this was fixed a disc of wire gauze. On turning on the gas and applying a light to the top of the wire gauze a non-luminous flame was obtained, which did not, of course, blacken any object upon which it played. As the admixture of air and gas in this arrangement was not exactly regulated, the temperature of the flame was often low, so much so that if the supply of gas were diminished, the flame went out altogether. Bunsen was not satisfied with this, and he said: "I am going to make a lamp in which the mixture of air and gas shall burn without any wire gauze." This, I thought, would be a difficult task, as a mixture containing ten volumes of air and one of gas becomes explosive and the flame would then pass down the tube to the nozzle where the gas escapes, and thus the lamp would be rendered useless. However, Bunsen, nothing daunted, made a large number of experiments on the relative size of the openings for gas and air, and

eventually the "Bunsen burner" came to light. This is now universally employed, not only for chemical but for a great number of other purposes in the arts and manufactures, so that this burner is even more widely known than the zinc-carbon battery which also bears his name.

Another well-known instrument invented by Bunsen (1844) is the photometer, which he devised for measuring the illuminating power of coal-gas. The essential feature of this apparatus is a disc of paper having a grease spot in the centre, a comparison of the luminous intensity being made when by the approximation of the source of light to the illuminated disc the spot becomes invisible. When the instrument was shown and explained to the late Emperor Frederick he remarked, "For the first time in my life I now know the value of a spot of grease."

It is not only his inestimable additions to pure Science, upon which this is not the place to dilate, that mark Bunsen as one of the foremost scientific men of his age; he is no less distinguished by his contributions to its industrial applications. Perhaps the most important of these was the revolution he effected in iron manufacture. He made the first successful attempt to introduce accurate scientific methods and inquiry into this great industry. Up to 1845 the production of cast-iron in the blast-furnace was carried on largely in ignorance of the scientific principles upon which it depends. The waste of fuel was enormous, amounting often to 80 per cent of the whole. Bunsen, by analysing the escaping gases from the blast furnaces at Alfreton, in Derbyshire, showed how this loss could be obviated and the heat of the burning gases utilised; and, in conjunction with the late Lord (then Dr. Lyon)

Playfair, he conducted a series of experiments which have resulted in economies the money value of which may be reckoned by millions of pounds.

Clear light was thrown by these researches in other directions upon the chemistry of the blast-furnace. For example, the formation of cyanogen in the furnace was unknown until it was discovered accidentally, as thus described by Playfair: "Bunsen was engaged below, and I above, passing the gases through water to collect any soluble products, when I was alarmed by being told that my friend had become suddenly ill. I ran down and saw white fumes coming out of a lateral tube, and Bunsen apparently recovering from a fainting condition. I applied my nose to the orifice and smelt the vapour of cyanide of potassium, which gave an entirely new light to the processes of the furnace."

These important results could not have been achieved if Bunsen had not previously elaborated an accurate method of gas analysis. No one before his time could undertake accurate determinations of the several constituents of a gaseous mixture. His book on gasometry—the only book he ever wrote—is a remarkable one. For originality of conception, for success in overcoming difficulties, for ingenuity in the construction of apparatus, and for accurate methods, this book as a record of experimental work is, I believe, unequalled. Many were the physical properties of gases which formed the subject of Bunsen's investigation. He devised new methods of attack; he invented novel instruments for effecting his object, and was thereby able to study with accuracy the phenomena of gaseous diffusion and absorption. All these researches were masterpieces of experimental skill and of accurate and painstaking work.

Bunsen had a keen sense of humour. One day a student came to him to request him to sign a certificate of attendance at his lectures, which he usually did without hesitation, adding the common expression, "mit ausgezeichnetem Fleiss." On this occasion, however, he hazarded the remark that he had not noticed the presence of the gentleman in question, for of course in the German Universities it is "frei lehren und frei lernen," no roll being called or note taken of either "absents" or "presents." The student then replied: "Yes, sir, and that is accounted for by the fact that I sit behind the pillar." "Ah," said Bunsen, "so many sit behind the pillar."

On another occasion one of his assistants, wishing to see whether the professor could give him off-hand the formula of a complicated organic compound, brought him a bottle containing a specimen of quinine which he was about to label. "Herr Professor," said he, "this is quinine. I have forgotten the exact formula—can you give it to me?" "Ach, Herr Doktor," said Bunsen, "wozu sind denn die Handbücher?"

The new laboratory drew a still greater crowd of students, and I became intimate with a large number of men who afterwards distinguished themselves in various ways. I have mentioned Lothar Meyer, who became the celebrated professor at Tübingen; and Hermann, who was the proprietor of some very large chemical works at Schönebeck. Among the rest were Beilstein, who became Professor of Chemistry at the Imperial Polytechnic in St. Petersburg, and the author of the classical work on organic chemistry; Pebal, who was professor at Gratz, and who many years afterwards was murdered by his servant; Frapolli, the well-known Senator at Milan; Pavesi, professor at Pavia; Schisk-

off, the Russian officer, who worked with Bunsen on the products of the decomposition of gunpowder, and who always said to me when I was talking English to my English friends, "Take the potato out of your mouth," he thought we mumbled so. Then there were Quincke, who afterwards filled, and still fills (1906), with distinction the chair of Physics at Heidelberg, and Bahr, the Swedish chemist. Concerning the latter I may interpolate a characteristic story. Bunsen was often very absent-minded. Bahr, with whom he was well acquainted, was with him one day when another Heidelberg professor came into the room. As sometimes happened, Bunsen had forgotten the name of his pupil, and wishing to introduce him to his colleague, he said: "Mr. ——, oh, I beg your pardon, but I never can pronounce your soft Swedish 'th'—won't you pronounce your name?" "My name is Bahr," replied the Swede.

Then there was Landolt, now professor in Berlin, and von Baeyer, Liebig's successor in Munich, and one of the most distinguished chemists that Germany has produced, besides others, many of them Americans, whose names at the moment escape me. There was also Lourenço, a man of Indian blood, from Goa, who afterwards became Professor of Chemistry at Lisbon. And last, but not least, was Kekulé, who, however, was not working in Bunsen's laboratory, but held the position of Privat-Docent, and had a laboratory and a small house in the Hauptstrasse, but who formed one of our coterie.

Amongst the Englishmen were Russell, Atkinson, and Matthiessen. The last named was a curious creature. Bunsen set him to work on the preparation of the alkaline-earth metals by electrolysis. He had an affection of the nerves or muscles, a kind of St. Vitus'

the next night; and thus he told the party the whole story, forgetting altogether that he was giving them an account of what was happening at the moment!

Six months after I first went to Heidelberg I passed the examination for the doctorate with my friend Pauli —he died a few years afterwards of phthisis. I chose for my subjects chemistry as a "Hauptfach," with physics and mineralogy as "Nebenfächer." I had also to construe a piece of Latin; and the only concession to my nationality was that I was allowed to translate into English a passage from the *Æneid*, which Bähr, the Professor of Latin, set me. The examinations were, of course, entirely oral, and I suppose I must have satisfied the examiners, for both Pauli and I received the degree "summa cum laude," an honour for me, as up to that time this highest degree had never been conferred upon a foreigner.

In the spring of 1854, in company with my mother and sister and Mr. Edward Enfield, who was engaged to my sister, I visited the most important cities in North Germany and saw the usual sights. Berlin at that time was not much more than an overgrown village, with detestable pavements, shabby vehicles, and medieval sanitary arrangements both as to water supply and sewerage. There I made the acquaintance of the two Roses—Heinrich and Gustav. The former occupied the only chemical laboratory open to students, and it was but a poor affair. Mineralogy, professed by the latter, was represented by a well-ordered museum, but any mode of teaching the subject otherwise than by inspecting the specimens was impossible. Then Gustav Magnus received me most kindly, as was his nature, and I saw the only physical cabinet and laboratory existing in Berlin in his private house. Dove, the celebrated meteorologist, whom I visited, had

likewise but little aid from the State. In short, when one now visits Berlin and sees the magnificence of its buildings and the extent and completeness of its educational institutions, it is hard to realise that this enormous development has been accomplished in the short period of half a century.

In the summer of 1854 my sister was married to Edward Enfield at the British Embassy in Berne, in presence of ourselves and the Crompton family, who were spending the summer on the Continent. I introduced Mr. Justice Crompton to Professor Mittermaier, of Heidelberg, who was highly flattered at making the acquaintance of an English judge, or "my Lord Crompton," as he called him, and they had a discussion—for Mittermaier spoke fairly good English—on the subject of English law, which was his speciality. After the interview I asked the judge what he thought of the professor's knowledge of English law. "Well," he said, "he has about as much idea of the principles and practice of English law as my boots!" But I hope the judge was a little hard on the old man.

In the autumn of 1855 I returned to Heidelberg and continued the work which I had begun with Bunsen on the chemical action of light, and this kept me busy. I remember that much of my work was done in the loft of the laboratory, a portion of which was boarded off for me—as I had to work in the dark—and the heat during that summer was abnormal. I used to work with very little clothing on, but stuck at it hard, week after week, meeting with all sorts of discouragements, but at last succeeding in obtaining the wished-for results. Bunsen was deeply interested in what I was doing.

After my appointment as professor in Manchester in 1857, of which more anon, I spent four summer

vacations in the years 1859–62 in working with Bunsen on photometrical measurements; and the results were printed in German in Poggendorf's *Annalen* and in the *Philosophical Transactions* in English. An appreciative reference was made to these researches by Ostwald in an appendix to his reprint in his *Collection of Scientific Classics.*

"The Photo-Chemical researches of Bunsen and Roscoe deserve the name of a classical investigation, as they not only have gathered together all points known hitherto on the subject, but by their wide and thorough experiments have laid the foundation for all further work on the subject. It cannot be doubted that these researches not only serve as *a* classical, but as *the* classical type for all future experimental work on the subject of Physical Chemistry.

"In no other research in this domain of science," he adds, "do we find exhibited such an amount of chemical, physical, and mathematical dexterity, of ability in devising experiments, of patience and perseverance in carrying them out, of attention given to the minutest detail, or of breadth of view as applied to the grander meteorological and cosmical phenomena of nature."

In this connection the following (translated) letter from Bunsen is of interest. It requires a word or two of explanation. On my return to England from Heidelberg for the Christmas holidays, 1855–6, I heard for the first time of Draper's previous work on a chlorine and hydrogen "tithonometer," and, somewhat downcast by this discovery, I wrote to Bunsen on the subject. His wise and encouraging words put new heart into me, and I returned to work at Heidelberg determined to do my best to prove equal to the task that lay before me.

HEIDELBERG, 13*th January*, 1856.

MY DEAR ROSCOE,

I think that Draper's experiments will not require to be repeated by us any more than Witwer's. Independently of much that appears to me to be inexplicable in them, the

pressure to which the luting liquid saturated with H and Cl is subjected constantly changes. I therefore conclude that Draper's instruments will not indicate proportionality, &c., especially as the volume of the isolated gas is so small compared with that of the luting liquid. At any rate I see no grounds for interrupting our experiments; still less do I consider that it is a misfortune that the results which we have obtained should have been to some extent previously described by him. It appears to me that the value of an investigation is not to be measured by whether something is described in it for the first time, but rather by what means and methods a fact is proved beyond doubt or cavil, and in this respect I think that Draper has left plenty for us to do. Do not, therefore, let your discovery of Draper's work disconcert you. I am now busy getting my *Eudiometry*[1] ready for press, and I hope by Easter to have made an end of it. My best greetings to Williamson, in hearty friendship.

Yours,

R. W. BUNSEN.

I naturally enjoyed greatly the close personal relationship with Bunsen which this work brought with it. A special room in the laboratory was assigned to me for carrying it on, and as the apparatus required supervision in the night, a bedroom was set apart for me in his house. It is almost needless for me to remark that without Bunsen's advice, assistance, and co-operation I should never have succeeded in obtaining the results we did; and although I carried out the experimental part of the work, the elaboration of the results was mainly due to him. Only those who have had the pleasure and the benefit of working directly with Bunsen can fully appreciate the value of his teaching and of his example, and this pleasure and benefit I had in abundance. I was usually able to get away from Manchester at the beginning of July and worked steadily in Heidelberg until the middle

[1] Translated into English by myself and published by Taylor and Walton.

or end of August, in the years from 1857 to 1862, when Bunsen and I, accompanied sometimes by Kirchhoff and sometimes by Häuser, the well-known historian, or by both of these intimate friends, made excursions into the Bavarian Highlands, the Tyrol, and Switzerland. I have often regretted that I never made notes of the incidents which occurred on these excursions, and of the humour and wit of my companions, especially of Häuser, which was a never failing source of amusement.

The years I spent at Heidelberg were among the pleasantest as well as the most fruitful of my life. Although I worked hard at my science and permitted no social engagements to interfere with the prosecution of my investigations, I fully appreciated the proverb that "all work and no play makes Jack a dull boy," and took care to enjoy my leisure hours in a variety of ways. I did not, however, join any of the "Studenten Corps," as I thought it poor fun to stand up to have one's face slashed at by a German friend or to try to do the same to him. Nor was I an adept in filling my skin with gallons of "small beer," and therefore did not frequent the "Commers," though I thoroughly enjoyed the "Frühschoppen" after a hard morning's work, and sometimes with a few choice spirits—of a chemical nature—went so far as to drink a "Salamander" to the progress of our researches.

Of exercise, beyond the "Fecht-Boden" of the Hirsch Gasse, the Heidelberg student was altogether innocent. He might walk—though he generally preferred to drive in a droschke—to some neighbouring "Bierlokal" where he imbibed his favourite beverage, and "renomaged" over his pluck when he last went "los"—that is, at his last duel. "Gestern," says one, "habe ich sechs nadeln bekommen." "Ja," replies

his friend, "aber letzte woche habe ich sieben gehabt." This practice of duelling must, I suppose, have its good side, as it is not only prevalent throughout German Universities, but shows few signs of decay, and yet it is to our English ideas a puerile form of assault, as the combatants are so protected by masks and bandages that the worst that can happen is that the cheek is cut open or the nose slashed across. No, much as we may think that our English sports are overdone, there is no shadow of doubt that the qualities of head and heart which are called forth in cricket and football go further in the making of character than does this German system of duelling, which, after all, is only practised by a fraction of the German students. The rest get no games or exercise in common of any kind, though gymnastics (turnen) takes a prominent place in German schools.

The Englishman, however, needs something of the sort to keep him going and out of mischief. So my friend the late Dr. Atkinson and myself bought an English-built skiff, the *Lady Margaret*, and, much to the astonishment of the humdrum Heidelbergers, disported ourselves—"verrückte Engländer" we were called—on the "Green Neckar," strengthening our muscles by pulling up the rapids to Neckar Gemünd, or running down the river to its mouth on the Rhine.

This brings to mind a scene which, though it happened half a century ago, is keenly impressed on my memory. One day, crossing the old bridge—the only one then—over the Neckar, I saw a young man punting up-stream in one of the native flat-bottomed boats. "That man is an Englishman," I at once exclaimed, for no young German gentleman was ever known to put himself to the trouble of punting alone up a rapid. And so it turned out, for the man was

no other than Leslie Stephen, who was staying at Heidelberg to learn the language. Soon I made his acquaintance, and this ripened into friendship which endured to the end of his life. His was a noble character, and it is a privilege, for which I am thankful, to have known such a man. My last sight of him, dying as he was by inches, was one never to be forgotten. We talked of old Heidelberg times and of our pleasant long-ago intercourse, and his eyes brightened and his voice trembled as he recalled some of its incidents.

To return to the German student, I always think that his foibles should be looked upon with an indulgent eye, and should not be allowed to overshadow his excellent qualities. He is a real good fellow and an intelligent. Quite as hard a worker as our Oxford or Cambridge average man, with more "Geist" and a far more thorough training. Whether his nine years of strict "Gymnasium" discipline have gone to make him a better man than our much more lax public-school system does for our boys is a matter about which much may be said. Of one thing I am certain: the average Eton boy could not follow as the German "Fuchs" (first year's man) does the high-class lectures on every conceivable subject, some of which he is bound to attend. This comes of his "Vorbildung" and of his appreciation of scientific method concerning which our undergraduate is, as a rule, altogether his inferior. Then the Germans with their "Lern- und Lehrfreiheit" are on the true University lines, whilst we, hidebound by examinations, are too apt to ignore, in our old system, the essential aim of all University life—the advancement of learning. That brilliant exceptions exist amongst us only proves the rule. It is in spite of, and

not by the help of, our plan of cram almost from birth to maturity, that the innate creative power of the Anglo-Saxon blood comes out. How much more might the race yield if originality were encouraged instead of being repressed and often destroyed by examination grinding, and if the freedom to teach and to study were in vogue with us as in Germany!

The oft-debated question of the tutorial *versus* the professorial system of training is one upon which I do not propose here to enter, save to call to mind that if the Universities throughout the world were asked to vote as to which system is to be preferred, only few hands would be held up for the former method against many for the latter. But, whichever system may be the favourite, one cannot help feeling that the hybrid method as practised at Oxford and Cambridge is an illogical one. Let us have one plan or the other. A friend of mine who took honours in the History Schools at Oxford told me that he never knew throughout his University career that Stubbs (one of England's great historians) lectured on history! Imagine, if you can, a German student of that subject not knowing that Häuser in Heidelberg or Treitschke in Berlin lectured on history.

Another equally intelligent friend supported the existence of University professorships by the argument that they were useful sinecures for distinguished persons!

In Heidelberg in the early 'fifties social festivities were on an old-world footing; now railways and telegraphs have modernised not only the town itself, but the manners and customs of the inhabitants. On one occasion we were invited to spend the evening with the Geheimrat, who was the Professor of Rural Economy, and what might be called a "stock"

German professor, very punctilious and precise. We sat down at table at three o'clock and never moved till ten. We began with tea and biscuits, followed by sponge cake with layers of jam, and went on with several courses and finished up with hot roast venison, the several items being washed down with wine. In those days society in Germany was of a somewhat formal character. Thus at the commencement of the proceedings all the ladies and all the gentlemen were ranged in lines on each side of the salon. An Englishman coming into the room and being presented to the ladies would naturally shake hands. This mode of salutation, however, was considered much too intimate, and in its place he had to institute a stiff bow with the feet placed in the "first position," and this to every lady in turn. The men and the ladies then kept studiously apart until the time for supper arrived.

CHAPTER IV

"BUNSENIANA" AND HEIDELBERG FRIENDS

Bunsen and Kirchhoff—Spectrum Analysis—Kelvin and Stokes—The 400th Anniversary of Heidelberg University—Bunsen Letters—Kopp —Helmholtz.

IN the summer of 1855 I visited the first Paris Exhibition in company with one of my German friends. At that time there was no antagonism between the two nations. Later in the same year I attended, for the first time, the meeting of the British Association held in Glasgow. Playfair was President of the Chemical Section, and he proposed me as secretary, and introduced me to the members as a young man of promise, who might some day succeed to the sectional chair. How little at that time did I think that I should be President of the Association in Manchester in the Queen's Jubilee year. In Glasgow I read a paper containing the result of work carried on conjointly by Bunsen and myself on the action of light on chlorine water, for he had invited me to join him in the work. It was afterwards published in the Journal of the Chemical Society and in Liebig's *Annalen*. At this meeting I made the acquaintance of many English chemists, and also had the good fortune to be introduced to Liebig, whom I afterwards visited in Munich on several occasions, and from whom I received a testimonial later on when I was a candidate for the chair of Chemistry at Owens College, Manchester.

During the summer of 1860 a remarkable gathering of chemists was called together at Carlsruhe, chiefly through the instrumentality of Kekulé. This had for its object the discussion of chemical nomenclature, which at that period was in a condition of chaos. The results, though not productive of the general agreement which was hoped for, were still useful, and the meeting marked an era in the progress of scientific chemistry, inasmuch as Cannizzaro here first set forth his system of the atomic weights of the elements which has served as one of the bases of modern chemistry.

Bunsen rarely attended such meetings, and it was only by extreme pressure that he consented to go. The subject under discussion was not one in which he took much interest, and he frequently said that one new chemical fact, even an unimportant one, accurately determined, was worth a whole congress of discussion of matters of theory. I accompanied Bunsen, and we stayed under the hospitable roof of Weltzien, Professor of Chemistry at the Polytechnic School.

The more serious business of the Congress was enlivened by many amusing incidents and by the great hospitality shown by the Carlsruhers. Among the guests was old Professor Despretz, of Paris, who was most anxious, on every occasion, to air his incomplete knowledge of the German tongue. He said to Schoenbein, of Basel, who was well known to all his friends as a "Plaudertasche," or, as we term it, a chatterbox: "Sie sind kein Deutscher; Sie sind ein Schwätzer [for Schweizer]!"

It has often been remarked that Faraday was Davy's greatest discovery. With almost equal truth it may be said that Bunsen's greatest discovery was Kirchhoff. I had left Heidelberg before the scientific twin brethren

had begun their memorable work on spectrum analysis, but on returning there in the summer of 1860 I soon came into the thick of it, and translated their epoch-making memoir in Poggendorf's *Annalen* for the *Philosophical Magazine*. I shall never forget the impression made upon me by looking through Kirchhoff's magnificent spectroscope, arranged in one of the back rooms of the old building in the Hauptstrasse, which then served for the Physical Institute, as I saw the coincidence of the bright lines in the iron spectrum with the dark Frauenhofer's lines in the solar spectrum. The evidence that iron, such as we know it on this earth, is contained in the solar atmosphere, struck one instantly as conclusive. And yet not more than forty years had elapsed since Comte in his *Système*, arguing that investigators should not waste their time in attempting the impossible, used as an example of what he meant by the impossible that the knowledge of the composition of the sun at a distance of 91 millions of miles must for ever remain unattainable. Now we know the chemical composition of the solar atmosphere almost as well as we know that of our own. But who can say how much more we have yet to learn of both? It was only a day or so ago that no fewer than four elements, hitherto unknown and wholly unexpected, were discovered in the air we breathe.

One of the most successful lectures I ever gave at the Royal Institution was that which I delivered on March 1st, 1861, on "Bunsen and Kirchhoff's Spectrum Observations." It is interesting now to remember that at that time no one in England had been able to project the bright lines of the metals on the screen. I had indeed heard that an optician in Paris, Duboscq by name, had done so with a certain amount of success. I wished, however, to try, and

I asked Faraday if he would allow me the use of the large Grove's battery belonging to the Royal Institution. He sent this down to Manchester, and I remember trying with all my might in the cellars of the old Owens College to throw the image of the spectrum on the screen, but I could not manage it. So I had an accurate reproduction of the drawings which accompanied Bunsen and Kirchhoff's first paper painted on glass. The interesting thing to show was that when a mixture of the salts of the alkali- and of the alkaline-earth metals was placed in the flame, the spectra of the most volatile of these metals made their appearance first; gradually, however, these died out, and then the spectra of the less volatile became visible. This appearance and disappearance I roughly accomplished by means of two lanterns, as in ordinary dissolving views, and the phenomena were thus clearly understood by everyone present.

I may here quote a letter which I received from Sir George Stokes in answer to a question as to his share in the history of Solar Chemistry; it is interesting, as it exhibits the modesty of the man and points out clearly the facts which have since then come to light as to the part played by Stokes and Kelvin in the discovery of the coincidence of the dark solar lines with the bright lines of sodium.

LENSFIELD COTTAGE, CAMBRIDGE,
7 Feby., 1862.

DEAR MR. ROSCOE,

My share in the history of the Solar Chemistry, I look upon it, is simply *nil*; for I never published anything on the subject, and if a man's conversations with his friends are to enter into the history of a subject there is pretty nearly an end of attaching any invention or discovery to any individual.

As well as I recollect what passed between Thomson and myself about the lines was something of this nature. I mentioned to him the repetition by Miller of Cambridge of Frauenhofer's observations of the co-incidence of the dark line *D* of the solar spectrum with the bright line *D* of certain artificial flames, for example a spirit lamp with a salted wick. Miller had used such an extended spectrum that the 2 lines of *D* were seen widely apart, with 6 intermediate lines, and had made the observation with the greatest care, and had found the most perfect co-incidence. Thomson remarked that such a co-incidence could not be fortuitous, and asked me how I accounted for it. I used the mechanical illustration of vibrating strings which I recently published in the *Phil. Mag.* in connection with Foucault's experiment. Knowing that the bright line *D* was specially characteristic of Soda, and knowing too what an almost infinitesimal amount suffices to give the bright line, I always, I think, connected it with soda. I told Thomson I believed there was vapour of Sodium in the sun's atmosphere. What led me to think it was sod*ium* rather than soda, chloride of sodium, &c., was the knowledge that gases that absorb (so far as my experience went) yield solutions that absorb in the same *general* way, but without the *rapid* alternations of transparency and opacity. Now if the absorption were due to vapour of chloride of sodium we should expect that chloride of sodium and its solution would exercise a general absorption of the yellow part of the spectrum, which is not the case. Thomson asked if there were any other instances of the co-incidence of bright and dark lines, and I referred to an observation of Brewster's relative to the co-incidence of certain red lines in the spectrum of burning potassium and the lines of the group *a* of Frauenhofer. I am nearly sure this is in a volume of the reports of the British Association being analogous to but not identical with Brewster's obs^{n} in the report for 1842, pt. 2, p. 15. (Since I wrote this I have looked through the indices of the vols. of the reports of the British Association and do not find it there.) Thomson with his usual eagerness said, oh then we must find what metals produce bright lines agreeing in position with the fixed dark lines of the spectrum, or something to that effect. I was, I believe, rather disposed to rein him in as going too fast, knowing that there were terrestrial lines (seen when the sun is low) which evidently take their origin in terrestrial atmospheric absorption where metals are out of the question, and thinking it probable that a large number of lines in the solar spectrum might owe their

origin to gaseous absorption of a similar character in the solar atmosphere. Even now I think it likely that some of the non-terrestrial lines in the solar spectrum may be of this character, though after what Bunsen and Kirchhoff have done I think it probable they are a minority.

The idea of connecting the bright and dark lines *by the theory of exchanges* had never occurred to me, and I was greatly struck with it when I first saw it, which was in a paper of Balfour Stewart's read before the Royal Society and printed in the Proceedings. I was wrong in saying *lines*, for B. Stewart considers only solids, the spectra of which don't present such abrupt changes. Stewart's paper was independent of, but a little subsequent to, Kirchhoff's, though the same idea with reference to radiant heat occurs in two papers of his printed in the Edin. Phil. Trans. and much anterior to Kirchhoff's paper. These papers I was not acquainted with at the time when Stewart's paper on light came before the R.S.

We can by no means affirm from the theory of exchanges that every dark line in the solar spectrum must be capable of reversion. For it may be due to absorption by a compound gas which is incapable of existing un-decomposed at the temperature requisite for becoming luminous, or which though not decomposed might yet have its mode of absorption completely changed, as we know that even a small elevation of temperature is sufficient materially to alter the absorption of light by NO_4 gas.

As to the mention of the metallic lines in the invisible region, I own to feeling a wish that the subject may be novel when I bring it forward, and yet I can't help feeling that that is mere selfishness and that I have no business to keep it bottled up. When are your lectures to be given? If not for some time perhaps I may draw up a note for the Royal Society for publication in the Proceedings which would of course set you quite free.

Yours very truly,

G. G. STOKES.

In 1862 I induced Bunsen and Kirchhoff to visit England. Kirchhoff had never done so, and Bunsen only some thirty years before, when, as a young man, Playfair took him to Alfreton to analyse, as already stated, the gases of the blast furnaces. I here

reproduce a photograph of Bunsen, Kirchhoff and myself, taken in Manchester in the above year.

During their stay in London we visited the Exhibition of that year and saw some of the usual sights of the metropolis, and I remember we attended a garden-party given by Mr. Gassiot, who lived in a large house at Clapham. It was a lovely day, and my two friends were very much struck with the beauty of an English garden; Faraday was there, and I introduced them to him. It was on this occasion that a lady, mistaking the chemist for the Chevalier Bunsen, addressed to him the question: "Pray, sir, have you not yet finished your great work on 'God and History'?" "Alas, no, madam," replied the chemist; "my untimely death prevented me from completing my task."

Of course Sir Charles Wheatstone invited us to visit him, and he talked with his usual emphasis about his own discoveries. Bunsen was much amused, and afterwards, when we were staying at Wastwater, at the Lakes, he fancied he saw a strong resemblance between Mrs. Ritson, the landlady, and Sir Charles, and remembered the place for years, often referring to "Frau Wheatstone" and the tame fox which was kept in the yard.

A characteristic episode occurred at Rugby, where my friends had promised to visit Mr. Charles Arnold, one of the Rugby masters, who had married a Heidelberg lady. Mr. Arnold had arranged for us to stay with him on Saturday night, and we were to go to my house in Manchester on the Sunday, as I had invited Dr. Joule, Professor Clifton, and other scientific friends to meet them. On the Saturday, Mr. Arnold said to me: "Oh, your friends will certainly stop over service to-morrow." I said I didn't know

and would ask them, and upon informing them that they were expected to attend service in the morning, they both expressed great unwillingness to do so, Bunsen saying that he had not been inside a church for seven years, the last time being at the marriage of his niece, and that he really didn't know how to behave! So I told Mr. Arnold that I was afraid we should not be able to manage it, as I had invited people in Manchester to meet my friends. Mr. Arnold, to my dismay, then said: "I have arranged it all; you can get out of chapel before the communion service, and so you will be able to catch your train." I then went to my friends and told them in German that there was no getting out of it, that they would have to attend service in the morning, and that they must make up their minds to it. So next day, to my great amusement, Bunsen appeared in a costume he very seldom indulged in, tail-coat, white tie, &c., &c., and on his hands a large pair of white kid gloves, and thus arrayed he accompanied us to chapel. The sight in the chapel at Rugby of all the boys in surplices is certainly a very interesting one, and my German friends were much impressed, Bunsen saying to Kirchhoff afterwards, "Do you know, I really felt quite devout." "Oh, nonsense," said Kirchhoff; "you were only sleepy."

Kirchhoff was, by common consent, one of the first scientific minds in Germany. He remained at Heidelberg until 1875, when he became Professor of Theoretical Physics in the University of Berlin. For many years he had not been strong, and had to go on crutches for some time in consequence of an injury to his foot. He died at Berlin in October 1886.

Bunsen had an irrepressible dislike to having his portrait painted, though he did not mind being photo-

graphed. Many years afterwards, my friend Dr. Mond was very anxious to have a good oil-painting of Bunsen, and he therefore commissioned Mr. Hans Schadow to go to Heidelberg and see whether he could paint his portrait without a formal sitting and without Bunsen's knowledge; and so the painter went, and, being well known to several of Bunsen's friends, he arranged with them that he should dine at the Grand Hotel at the same table where Bunsen usually had his midday meal. Whilst Bunsen was engaged in lively conversation he narrowly observed him and secretly made sketches on his knee of his various expressions, and from these he painted a likeness of the old man.

From 1857, on my appointment in Manchester, to 1863, the year of my marriage, I invariably spent the long vacation working with Bunsen at Heidelberg; the chief result of such work was the publication of the photo-chemical researches already referred to. I followed up these investigations in subsequent years, describing an automatic arrangement for registering the chemical action of light by the blackening of standard silver paper. A form of the apparatus designed for meteorological purposes was made for me by Horace Darwin, of Cambridge. A description of the method was published in the *Philosophical Transactions* (Bakerian Lecture, 1865); it worked extremely well, but has not yet been generally adopted in observatories, as I had hoped it would be.

In the year 1886 the eighth Jubilee of the foundation of Heidelberg University 400 years before was celebrated, and I was invited to be present and was one of the few to whom an honorary degree (in my case M.D.) was given. The festivities were of an unusually interesting character. Processions illustrating striking events

in the history of the University were got up with characteristic German accuracy. The Castle was, of course, illuminated, and a reception was held in one of the Castle halls by the Grand Duke. To this Bunsen and myself were invited, but he expressed great unwillingness to put on his gala costume with his orders pinned on to his coat, but at my serious insistence he agreed to accompany me. As we walked up to the Castle, as luck would have it, the Royal carriage containing the Grand Duke and Duchess and her brother the Prince Frederic of Prussia could not get through the crowd and came to a stand directly at the point which Bunsen and I had reached. He, of course, was at once recognised and addressed by the Grand-Ducal party, a *rencontre* which my friend especially wished to avoid.

On another day I had the honour of being introduced to the Prince of Prussia and had a long conversation with him in English. He was, as all the world knows, a man of splendid presence and also of great geniality and simplicity. I noticed that his hand was bound up, and on inquiring the cause he replied, "Oh yes, a little accident occurred to me the other day; a box of matches exploded in my hand and burnt me slightly,"—treating the whole matter as a mere triviality.

Among other incidents which occurred on that occasion I remember that the formal oration was given by Professor Kuno Fischer before the Grand-Ducal party in the large Protestant church in the Hauptstrasse. The temperature being high and the address very long and tedious, the effect upon the audience was, as might be expected, soporific. Bunsen lapsed into a calm state of unconsciousness, but on a more than usually impressive sentence disturbing his rest he

whispered to me, "I was dreaming that I had let a test-tube full of cæsium fall on the floor."

Concerning the preparations for the Jubilee and the invitation to me to take part in it, the following translation of two characteristic letters from Professor Kopp is of interest :—

Our University has had many difficulties over the invitations to this Jubilee to other Universities and Academies, to former Professors of this University and also to high State and Court officials (I have called the Jubilee week August 2–7 the Passion-Week and "I wish it was time to sleep and all was well"), in trying to cut down the number of representatives of these corporations (all are to be guests of honour and are to stay with members of the University), and also in trying to find room for them at the banquet (we have no room in Heidelberg large enough, and there are many reasons for its not taking place in "Noah's Ark"—a huge place which has just been put up as a "hall of ceremonies" on the Neckar, and where many can get light refreshments, though it is unsuitable for the banquet). On these accounts the invitations abroad had to be limited to the smallest number of Universities and Academies—in most cases one for each country. And I hear from the latest reports that the Victoria University will not be included. But you, old Heidelberg student, if you come to the celebrations you will not only give intense pleasure to all your friends here but I will also guarantee all the necessaries of life so that you can encounter the "struggle for existence." Everyone's wants on those days—even those of the inhabitants—will have to be modest; *à la guerre comme à la guerre.* I shall have to manage as best as I can *en garçon*; for my wife will go to Freiburg to our daughter there—I would not have her here at that time on any account.

Bunsen is well, as busy as usual with lectures and in the laboratory, and sends you his love. My wife sends you her kindest regards.

Your devoted

HERMANN KOPP.

Couldn't you come as F.R.S.? So far as I know, this Society will be asked to send one representative. If not come as (I nearly wrote "Good old") Roscoe!

On the same occasion it was proposed by myself and others to honour Bunsen by a dinner given to him by his former students who were present at the Jubilee, an invitation which he was unable to accept.

HEIDELBERG, *June 27th*, 1886.

DEAR FRIEND,

I will not put off answering your letter received yesterday. Bunsen's health is as good as we can expect at his age. With regard to the dinner which his former students intended to give him, he quite understands how much honour, attachment, and thanks they wish to show him, but, owing to the necessary fatigue entailed by the Jubilee week at which he will have constantly to be present, he fears he cannot name a day to set aside for this dinner. If he will feel strong enough after the Jubilee is over to attend the banquet proposed by his pupils, I cannot of course say, but I think it is better for me to explain matters a little. At Bunsen's age, naturally, he often speaks of retiring from his profession, particularly when he is not feeling well or if any difficulties arise. Were he really to carry this out I should deem it not only as very serious for science in general and a calamity for our University but also as very critical for Bunsen himself, for if he no longer had his former employment, old age would creep on much more quickly. By keeping on old occupations one preserves something of one's youth and repulses thereby the march of time. Bunsen will retain his activity all the longer the more regular his life is and the less interruption of any sort he has to undergo. I think you will agree with me in this matter and that it will be best for us to wait until the end of the Jubilee week to see how he is; if then he feels well enough he could have a special gathering of his former students who will be here then.

Your faithful

HERMANN KOPP.

At a later time, after he had retired into private life (1889), I was not infrequently a guest at his house in "Bunsen Strasse," when we fought our battles o'er again and I recounted to him things which had taken place in England. Above all he was interested in murder cases, of which in England we had about that

time some startling examples, and these I would tell him in great detail. The interest which he took in these cases was in no degree due to a morbid seeking after horrors, but entirely to scientific appreciation of the value and trend of evidence. It was in reading trials such as that of Palmer, where conviction was obtained in spite of the fact that no poison was found on the body, or that of Madeleine Smith, where the verdict was given of non-proven although death from antimonial poisoning was ascertained, that Bunsen found relaxation. He was also an omnivorous reader of light literature; his table was loaded with books sent in on approbation from the "Museum" Library, and he easily judged of their contents without cutting them open.

Although he was, in his latter years, unable to walk far, as had been his habit formerly, he enjoyed the beauties of mountain and forest as keenly as ever, driving through the chestnut woods which extend to the Königsstuhl.

Gradually failing in strength and health, but always, as he once wrote to me, "able to enjoy the humour of life," he peacefully breathed his last on August 16th, 1899. A singularly touching portrait of Bunsen in his later life faces this page.

The obituary notices which appeared in the Press did him, I think, justice both as an investigator and as a true and noble-hearted man. It naturally fell to my lot to write some of them; and in the *Times* on the morning following his death, and in *Nature* of August 31st, 1899, I was able to give sketches of the man and his work. I wrote similar notices for the Royal Society; and, lastly, I gave a more complete account of him in a Memorial Lecture read before the Chemical Society, of which he had

long been a Foreign Member. In this memoir I endeavoured to give not only an account of his scientific achievements, but to picture the man as he lived and worked; and I venture to think that my endeavour to honour the memory of my great friend was not unsuccessful, as the memoir was not only reprinted in America by the Smithsonian Institute and by this means widely circulated, but was translated into German by Professor Ostwald, and then placed as a preface to the collection of the works of the great master which was published by the Society in Germany founded in his honour and called "Deutsche Bunsen-Gesellschaft für Angewandte Physikalische Chemie."

During the long period over which our friendship extended, I received from Bunsen a large number of letters containing not merely matters relating to our investigations, but to incidents in connection with his own. Especially touching to me were the constant expressions of esteem and affection which they contained. I quote only five of the 126 letters which he sent me.

Feeling that these letters ought in some way to be carefully preserved, and knowing that Bunsen had expressed objection to the publication of his correspondence, I offered them to the President of the Bunsen-Gesellschaft for safe keeping. This offer was thankfully received. I had the letters carefully bound, through the kindness of Sir Edward Maunde Thompson, by the binders of the British Museum, and a very handsome volume they made. Thus the letters will be preserved for ever by the Society which honours itself by taking Bunsen's name.

The letter of which the following is a translation was printed in facsimile in my Bunsen Memorial

Lecture given before the Chemical Society. It is of special interest as it is the first communication of the discovery of spectrum analysis by Bunsen and Kirchhoff. It also gives an idea of the way in which he and I worked together in our photo-chemical researches.

HEIDELBERG,

November 13th, 1869.

My best thanks, dear Roscoe, for your last letter. Your induction experiments appear to me to be very important and interesting. From our former experiments I consider it certain that considerable induction takes place with our rotating disc, and from further experiments which I have made since then I have obtained the same results by exposing the paper on its reverse side; whilst according to my last experiment the duration of the insolation as compared with that when the light is cut off lasts frequently from $\frac{1}{500}$ to 20 seconds. If we assume that the induction in the case of the chloride of silver paper passes off very quickly, this would not be noticed in your experiments, whilst with the rotating disc it would become visible. A new apparatus about which I wrote to you will do all that we hoped. Unfortunately the weather is not favourable for me to make experiments; but I hope at Christmas or Easter to have obtained results for which we have so long striven. At the moment I am occupied by an investigation with Kirchhoff which does not allow us to sleep. Kirchhoff has made a totally unexpected discovery, inasmuch as he has found out the cause for the dark lines in the solar spectrum and can produce these lines artificially intensified both in the solar spectrum and in the continuous spectrum of a flame, their position being identical with that of Frauenhofer's lines. Hence the path is opened for the determination of the chemical composition of the sun and the fixed stars with the same certainty that we can detect chloride of strontium, &c., by our ordinary reagents. By this method the chemical elements occurring upon the earth may also be detected and separated with the same degree of accuracy as upon the sun; for example:—In 20 grams of sea-water the presence of lithium can be shown. In the detection of many elements this method is to be preferred to all previously known processes. A mixture contains Li Ka Na Ba Sr Ca; all that is necessary is to bring a milligram of this mixture into

our apparatus in order at once, by help of a telescope, to read off the presence of all these bodies by a simple observation. Certain of these reactions are of a marvellous degree of delicacy; thus, for example, one can detect $\frac{5}{10000}$ part of a milligram of lithium with the greatest ease. I have myself observed the presence of this body in almost all specimens of potash.

Your

R. W. BUNSEN.

The following letters describe two most unfortunate events. The first refers to an explosion by which Bunsen was seriously burnt; the second gives an account of a singular incident which befell him, reminding one of the well-known accident which happened to Isaac Newton, only in this case it was the sun's rays shining through a globular water-bottle instead of the dog Diamond that brought it about. The first accident was the occasion of a remarkable outburst of enthusiasm on the part of the Heidelberg students. It was reported that Bunsen had lost his eyesight. Next morning the whole of the Wrede Platz in front of the house of their beloved teacher was crammed with an anxious crowd awaiting the report of the doctor, and when he appeared on the balcony and stated that no serious damage had been done, the shout of joy which rent the air was one not to be forgotten. In the evening the "boys" gave Bunsen a "Fackel-Zug" and sang "Gaudeamus Igitur" under his window.

HEIDELBERG,

May 24th, 1869.

MY DEAR ROSCOE,

It is still rather difficult for me to write as my hands are not quite healed, but I cannot delay any longer my answer to your friendly sympathetic letter, as I do not wish you to be uneasy about me. The cause of the explosion is to me still quite inexplicable. I had prepared

about a pound of a mixture of metallic rhodium and iridium by reduction with zinc according to a method which I have described, and dried it on a water-bath to 100° C. On lightly touching the finely divided metals, not yet quite cold, with my finger, the whole mass exploded as rammed-in powder does; and this is all the more puzzling, as I have often rubbed the same sort of powder violently in a mortar in similar quantities from other platinum residues entirely without danger, and heated similar preparations of this kind red-hot in vacuo without any gas being given out, and certainly no hydrogen gas. My left hand, with the first finger of which I touched the mass, saved my eyes, as my face and eyes were only superficially burned by the flames which penetrated through my fingers. My eyes are now unhurt, with the exception of singed eyebrows and eyelashes, and so the whole explosion will leave no serious results behind. I have begun my lectures again.

I have not read anything for a long time with so much pleasure and satisfaction as your interesting lectures, and I am looking forward very much to the continuation and to the whole, which you are going to send to me and Kirchhoff—who, by the way, sends kind remembrances. I am convinced that the Vieweg translation will shortly be out of print. Kirchhoff was very much pleased with the new and astonishing sun observations. When you come in the summer—and we are delighted at the idea of seeing you—you must give us more detailed information verbally about these interesting discoveries.

Heartily yours,

R. W. BUNSEN.

HEIDELBERG,

June 3rd, 1874.

MY DEAR ROSCOE,

You have good cause to be very angry with me, *i.e.* for only answering your friendly and sympathetic letter; but I have lately not dared to think of anything which would remind me of the loss of my burnt researches, and was under the impression that I had written to you and thanked you for your sympathy, when in fact your friendly letter lay still unanswered underneath my papers.

I was about to collate experiments on which I had been working for nearly three years, before despatching the fair copy to Poggendorf for publication. On my return after a

short absence, I found all these papers, which had caught fire, a glowing heap of ashes. The photographs of the apparatus, and the drawings of all the spark-spectra, namely, those of the rarer earths, to separate which had cost me untold trouble —all, all burnt!

Yours ever,
R. W. BUNSEN.

To conclude the subject of Bunsen, I am pleased to be able to add the following picturesque description by my friend Thorpe of his introduction to the master :—

MY DEAR ROSCOE,

You are good enough to ask me to tell the story of my first acquaintance with Bunsen. I well remember the circumstances. Indeed, thanks to your good offices, I look back upon the years I spent in the Heidelberg laboratory, in close association with that great man, as one of the most precious memories of my life. You may remember you sent me to Heidelberg with a scholarship awarded on your recommendation by the trustees of the old place in Quay Street, and for which I can never be sufficiently grateful, for it meant everything to me at that time. I had tried my 'prentice hand at a little bit of research—carbonic acid in sea-air—and you had the temerity to believe that with encouragement and assistance I might do better. Years afterwards I learned from our old friend Mr. Aston, the legal adviser of the College, that the award of that scholarship settled a constitutional question: it brought the Atlantic Ocean within the purview and jurisdiction of the Council.

Well, in the autumn of '67 I set out for Germany, fortified with much good advice, and the bearer of sundry presents from you and yours to Bunsen—among them a copy of the *Times* containing an account of a "horrid murder" (you remember the dear old man's amiable weakness for "horrid murders"), a small consignment—I think from Mrs. Roscoe, your mother—of potted shrimps (another amiable weakness), and above all some magnificent specimens of potassium and sodium (calculated to go straight to his heart) from Mather's works at Patricroft. Sonstadt had worked out Caron's process for the manufacture of magnesium, and there was what we then considered a great demand for the metals of the alkalis.[1]

[1] Sodium is now manufactured electrolytically to the amount of many thousands of tons annually.—(H.E.R.)

After a leisurely journey up the Rhine—I remember seeing the white-coated Croats in garrison at Mayence—I found myself in Heidelberg and lost no time in presenting myself to Bunsen, armed with the copy of the *Times*, the potted shrimps, and the precious box containing the alkali metals. Although it was still vacation time Bunsen had returned to work. I was ushered into the little room you know so well overlooking the Wrede Platz. The great man—great physically as well as intellectually—rose from the table at which he was writing—I see him now—and motioned me to the sofa. He evidently was not unprepared for my coming—I suppose you must have informed him. I duly presented your letter of introduction and, after answering his many tender inquiries concerning you, moved up my heavy battalions. I received a momentary check, however, for, owing partly to his slight deafness but much more to my imperfect knowledge of German, he moved across to the sofa the better to hear me, and sat down on my hat! I at once brought the *Times*, the potted shrimps, and the alkali metals into action. The "horrid murder" he would read at bedtime: the potted shrimps would certainly be appreciated in the morning: and we prepared ourselves for the alkali metals. The servant was called to unpack the box, when to my consternation he produced a bottle—I remember it was an old pickle-bottle—partially filled with naphtha, at the bottom of which were a few tablespoonfuls of a bright shining and rather mobile fluid. I had given the Geheimrath such a glowing account of the size of the sticks of the two metals that I was simply speechless with astonishment and felt indeed rather like an impostor. I had never realised so vividly before the possibility of the transmutation of metals. "Well," I said at last, "potassium and sodium were certainly put into the bottle before I left home, but what is there now is uncommonly like quicksilver." "No," said Bunsen, who was holding the bottle, "it is not quicksilver. Feel the weight of it!" The fact was that our old friend Heywood, who had been ordered by you to pack the specimens at the time in separate bottles, perceiving that both could be got into one bottle, had, with the charitable idea of not encumbering me with too bulky a package, placed the two metals together with the untoward result I have indicated. Chemical combination between solids is not of very frequent occurrence, but that it is possible under certain circumstances has never been forgotten by me. I had no knowledge at the time of the existence of this fluid alloy—nor had Bunsen—which, perhaps,

is not very creditable to us since it is actually mentioned by Davy. As an historical fact I believe the first so-called potassium isolated by Davy was fluid at ordinary temperatures owing to the amount of soda in the electrolysed potash. I still recall Bunsen tilting the bottle back and fro to observe the flow of the shining mobile fluid. (A few days afterwards he told me all that was then known of this fluid alloy and referred me to Gmelin's *Handbuch.*) I assure you I felt a little limp at the moment—more limp, indeed, than my crushed hat—and, the conversation flagging, he suggested that he should show me the place where he intended that I should work. It was in his own little laboratory, a couple of benches away from him, and where I had as companions Victor Meyer and an American—Gideon Moore—a man of extraordinary ability, who had the misfortune to be stone-deaf but who taught himself German and spoke it fluently without having heard a sound of the language.

We then passed into the lecture-theatre, and, stepping across the room, he pointed to a picture on the walls. It was a plate from the *Phil. Trans.*—the curves of the chemical intensity of daylight, which I had measured for you in Portugal, or in the Brazils—I forget which. This he had caused to be framed, and placed in the lecture-room. I felt that after all I had not lived in vain.

I could run on interminably with my reminiscences of "Papa" Bunsen, as we affectionately termed him. How affectionately we, and not only his own students but the whole University, regarded him may be illustrated by the following incident of which I was witness. It was during my time in Heidelberg that Bunsen experienced the explosion which nearly cost him the sight of his remaining eye. It occurred at night time when he was alone in the laboratory, and was probably due to the escape of occluded hydrogen from a large quantity of reduced mixed platinum metals over which he incautiously held a lighted taper. Next morning the rumour ran round the town that Bunsen was blinded, and the Wrede Platz was packed with students and burghers anxiously inquiring if the news were true. No certain information could be gained, and the crowd swayed backwards and forwards throughout the day waiting for tidings. It was late in the afternoon before a proper examination could be made, when it was discovered that the eye was safe. Friedrich, the surgeon, promptly stepped out on to the balcony to announce the fact, when the air was simply rent with huzzas, caps went up, men embraced each other, women wept. Such a scene I

never witnessed before, nor have I seen the like of it since. If the cheers reached the darkened room in which the dear old man was sitting—as indeed they must, for the noise was terrific—he must have gathered how strong was the hold he had on the affections of the whole place.

Working literally side by side with Bunsen, I naturally saw much of him. Although our teacher, he was to all intents and purposes as much a student as the merest tyro. He had no more bench-room than anybody else, and was subject to the same disciplinary rules as the others, paying up his kreutzers with an affectation of dismay when caught wasting the gas, or leaving the balance case open, or committing any other of the one-and-twenty cardinal sins by which, when discovered, we supported the library.

Of his almost paternal interest and kindness to me I could give many instances, but one must suffice. The day came when I was to be indoctrinated into the art and mystery of gasometric analysis—Bunsen's gasometric analysis—and by Bunsen himself. It was a red-letter day, and I determined to mark it by purchasing the finest eudiometer Desaga stocked. With his help I picked out the longest, straightest, and widest in the shop, and returned in triumph with it to the laboratory. As I passed through the swing door I came upon Bunsen, who asked me what I had got. I showed him the instrument: it met with his approval, but, taking my hand, he showed me to his own amusement but to my consternation and disgust that my thumb could not possibly close it. He then proved to me with what ease he himself could close it: his right thumb indeed by constant use was like a pad, and to my astonishment much larger and wider than that of the left hand. I am afraid I must have looked, as I felt, rather foolish and chap-fallen as I gazed on my incompetent digit. But he sought to cheer me with the remark: "Sie mussen recht viel arbeiten und es wird grosser werden." I regret to say, however, that I never succeeded in closing that eudiometer as Desaga sold it to me.

On another occasion I had a *rencontre* with Bunsen in which I scored a little better. It was at the time of my examination for the doctorate. As was his habit, he led off with some simple easy question. He asked me how many oxides of nitrogen there were. I have a nebulous sort of notion that I fancied at the time such a question was almost an insult to my intelligence. I promptly gave him the number. He demurred to there being five. I felt at a loss what to say until, glancing at Kopp sitting in the rectorial chair—

in which, by the way, he seemed to be but faintly visible—I got an encouraging nod. I reiterated my belief as to the number. I was then called upon to name them. When I came to the last, Bunsen expressed his incredulity as to its existence. Something in my look must have impressed Kopp, for when I looked again at him the nods were more emphatic than ever. You know how in moments of peril one's senses are quickened and the faculty of recollection is sharpened. Such a moment had come to me, and luckily I was equal to it. Some time before I left for Heidelberg you had expressed a wish to repeat Deville's work on nitrogen pentoxide—I don't think we called it nitrogen pentoxide in those days—and bade me get the subject up, which I did. Although I had not seen the paper for some years, the whole matter now came back to me with perfect distinctness. I could visualise the pages in the *Annales de Chimie* where the memoir was. I seemed to see the title and the number of lines below it, and I mentally unfolded the plate on which the apparatus needed is figured. I quickly got to work, and I think it was soon evident to the rest of the Faculty, most of whom—Kopp excepted—probably knew nothing whatever about the matter, that I had good reason for the faith that was in me. Bunsen appeared to be genuinely interested, and when I had finished, amidst a shower of approving nods from the dear old Pro-Rector, he wound up by asking who was the discoverer of the wonderful compound I had described. "Henri Etienne Saint-Claire Deville," I answered. "Oh! a Frenchman!" he cried. Whereupon the whole Faculty laughed in chorus, Bunsen included. Although I seemed to myself to "romp in" apparently an easy winner, I had and still have a suspicion that the shrewd old man, with artful simplicity, was "pulling my leg" all the time.

The last occasion I saw Bunsen was after a visit to Stockholm, where Pettersson and Arrhenius had shown me the laboratory of Berzelius, restored as far as practicable by the pious care of the librarian of the Academy. It was most interesting to me to look over the specimens—a sample of Wöhler's synthetic urea, racemic acid, the vanadium specimens, bits of selenium, &c., and to see the old apparatus. Bunsen had then retired, and I found him a cheerless, solitary man, unable to read, and physically very feeble. I gave him an account of what I had seen. "But the place was only a kitchen!" he exclaimed. "Yes, but such a kitchen! There was never a kitchen like it,"—with which

he agreed. And then I told him I had discovered a water-colour drawing of Old Anna in a curiosity shop in Stockholm, which Arrhenius forbade me, for the honour of his country, to take away. Whereat he smiled. And then he began to talk of old times. We had had, or were about to have, the Jubilee dinner of the Presidents of the Chemical Society, and he spoke of Playfair, and of the first Mrs. Playfair—a memory I did not probe—and seemed tickled with the picture he conjured up of the little Red Lyon in a very big wig. He apparently imagined that the Chairman of Committees is arrayed in all the Speaker's glory. We had a delightful half-hour, and it was pleasant to see how he seemed to glow once more with the old bright smile that we know so well. I rose to go, and, expressing my pleasure at finding him as he was, said I hoped to see him again before very long. He took my hand between his. "No," he said, "you will see me no more." And so it proved. I had looked upon him for the last time.

Yours very truly,

T. E. THORPE.

On looking back upon the life and interests I had in Heidelberg, I do not think that such a time existed there before, or has done since. Such distinguished friends as Helmholtz, Bunsen, Kirchhoff, Kœnigsberger, and Quincke as men of science, and I may add Haüser and Vangerow as men of letters, besides eminent representatives of other professions, will never meet together again.

Amongst these great men the figure of Helmholtz stands out pre-eminent. To use the words with which as President I welcomed him as Faraday Lecturer to the Chemical Society, "eminent as an anatomist, as a physiologist, as a physicist, as a mathematician, and as a philosopher, we chemists are now about to claim him as our own."

The title of the lecture was "On the Modern Development of Faraday's Conception of Electricity" and the lecture may truly be said to have been a

turning-point in the history of the subject and to have laid the foundation of our present ideas of the theory of electrolysis.

The following letters (translated) from Helmholtz indicate the great amount of trouble which he took in connection with this lecture :—

November 21st, 1880.

HONOURED FRIEND,

I am quite ready to give the Faraday Lecture for 1881 if it can be arranged to take place between the 15th March and the 22nd April. Of late I have been working partly upon electrolysis and partly upon electro-dynamics, more or less on Faraday's lines, and I will try how much of this I can make suitable for chemists without becoming too abstract.

I saw our old friend in Heidelberg in September. He was well and happy, although he speaks about wishing to retire.

My kindest regards to your wife.

Yours,

H. HELMHOLTZ.

January 3rd, 1881.

HONOURED FRIEND,

If the Council of the Chemical Society already wish to publish the title of my Faraday Lecture, I think of calling it something like this : "The Modern Development of Faraday's Ideas on Electricity." Can you think of a better English expression for it? (*Die neuere Entwickelung von Faraday's Vorstellungen vom Wesen der Elektricität*). If so, please suggest it. I will write my address in English. If you will then kindly take the trouble to read it through and correct all that does not please you, I should be very grateful to you. I do not as yet know how far I dare attempt to perform experiments. In a strange place with strange apparatus it is always risky. Besides that, Professor Tyndall writes me that there will only be an hour between the closing of the last lecture and the beginning of mine, and therefore that would give but little time for preparation. The phenomena of which I shall have to speak are undoubtedly known to most chemists, and I shall probably only have to set out the apparatus in order to explain what I mean shortly and quickly.

Many thanks for your friendly invitation to stop with you. I accept for myself with great pleasure; my wife has not quite decided yet what she will do.

With kindest regards to your wife,

Yours,

H. HELMHOLTZ.

PARIS (undated).

HONOURED FRIEND,

I have come safely through my expedition in England, Ireland, and Scotland, given my lecture in Dublin, spoken at the Royal Society of Edinburgh, and ended up by staying with Sir W. Thomson. Every moment of this entire time was so filled up that I was quite unable to write the short notices necessary for the completion of the Faraday Lecture for publication. To-morrow night we go to Berlin, and will get there on Monday evening. Meanwhile the Editor of the *Journal of the Chemical Society* has sent me a copy of the present text with the request that I should revise it speedily. In any case I will send it off from Berlin if I do not find a quiet moment here to finish it off. Should it be necessary to get it through very quickly in order to insert it in the June number, I beg you to send me a post-card to Berlin to that effect. My time has been so occupied ever since my lecture at the R.I., what with preparing my next lecture and making appointments to see people, that I have had no time to get through this revision.

Once more, many and hearty thanks from my wife and myself to you both for our delightful stay with you, and for the great sacrifice of time you gave on my behalf.

In true friendship,

Yours,

H. HELMHOLTZ.

In 1861, Helmholtz married our friend Anna von Mohl, and their house in Heidelberg became the resort of all that was best and intellectual, not only there, but from all the world over. Helmholtz was certainly, taking him altogether, the most wonderful man I ever knew, and his character was as charming and simple and his heart as kind as his intellect was great. He was not merely an eminent *savant*, but a polished man

of the world, as much at home among princes and grand-dukes as he was in his laboratory among his students. Our two families became intimate, for the Helmholtzes frequently came to England and stayed either at my sister Mrs. Enfield's house in London, or with us in Manchester. Frau von Helmholtz was as charming in her way as he in his. She outlived her husband by a few years, and died on December 1st, 1899. A beautiful notice was written shortly after her death by Marie von Bunsen, grand-daughter of the Chevalier, which contains the following appreciation: "A man leaves his mark on the world by works and deeds, but a woman who neither courts publicity nor attempts authorship cannot acquire fame, and yet Anna von Helmholtz may truly be said to be one of the most remarkable of German women."

Frau von Helmholtz had a highly sensitive and active temperament. I remember that on the morning of the day on which he was to deliver the Faraday Lecture she came down to breakfast and amused us by saying that she had been so nervous about the success of his lecture that she felt in the night as if she should die; upon which he remarked in his calm, equable manner, "Ach, dass geht nicht so schnell."

Helmholtz was a very temperate man; he never smoked, and I remember his saying that he found that the smallest quantity of alcohol dispelled from his mind "all his good ideas," as he used to express it, by which he meant that if any great problem had to be thought out, this was only possible when his brain was free from alcoholic taint.

Apropos of this, one of the most interesting facts about the human body is its power of accommodation as well as its sensitiveness to stimulant. Think of the quantity of laudanum De Quincey used to take

with impunity; and on the other hand Bunsen, who was a great smoker, could not drink tea. He used to say that if he drank a cup of tea even at breakfast, and certainly in the evening, it would keep him awake during the whole night. Again, one has seen many men who would be completely upset by smoking a cigar, who yet, like Johnson, would drink any number of cups of strong tea at night and sleep well afterwards.

Another instance of the accommodating power of the human body occurred to me many years ago (1861). I investigated the question of the alleged power exhibited by the Styrian peasants to eat arsenic. This was laughed to scorn by Dr. Alfred Taylor in his well known book on Toxicology, but it turned out to be perfectly true. I obtained evidence through my friend Pebal, who was professor at Gratz, which not only satisfied me, but everyone who took the trouble to go into the question, that the peasants in Styria are able to swallow with impunity four times the amount of what is usually a fatal dose of white arsenic. I obtained a sample of the materials used by these peasants—they call it "Hidrach," which is a corruption of "Hüttenrauch," thus showing the origin of the material—and it turned out to be pure arsenious oxide. The object of their taking arsenic is said to be to preserve their wind in carrying loads up the mountains. Whether it did so or not I do not know, but any doctor who prescribed four grains of arsenic would very soon be brought up for manslaughter if not for murder; and yet those peasants took that quantity with impunity.[1]

[1] Micro-organisms can also, like macro-organisms, be gradually accustomed to doses which are absolutely bactericidal to the same species when not so acclimatised, and the ready acclimatisation of bacteria to poisons is now generally admitted (Metchnikoff).

To return to Helmholtz. When I was last in Heidelberg I had an interesting conversation about him with Koenigsberger, the well-known Professor of Mathematics. They had been on most intimate terms. Koenigsberger had just written a most valuable and elaborate *nécrologe* of his great colleague. In a letter to me, he remarks that it was always interesting to listen to Bunsen and Kirchhoff dispute about some mathematical, scientific, or philosophical subject. Still more interesting was it, however, to watch, when he was present, the incomparable Helmholtz looking silently on from his calm Olympian heights with an appreciative and meaning smile as the discussion proceeded. He also spoke to me about the very great admiration which Helmholtz had felt for Clerk Maxwell's work. He said that he (Helmholtz) considered Maxwell superior to himself as a physicist, and often spoke of him as if he were inspired.

Perhaps the most striking example of Helmholtz's many-sidedness was shown on the anniversary of his seventieth birthday, when deputations, not only from all the German universities, but from a great number of distinguished persons from the Emperor downwards, and from scientific and other associations of various kinds, presented addresses of congratulation to him. To each one of these he replied, apparently without effort, and certainly without preparation, in the most varied and appropriate language, alluding in the case of each deputation to the special points of most interest to them. To his scientific labours I do not intend to refer: those who are interested will find them mentioned in Koenigsberger's excellent *Life of Helmholtz* published by Vieweg; or in the touching and able Memorial Lecture delivered before the

Chemical Society in January 1896 by my distinguished and lamented friend Professor FitzGerald of Dublin University.

Helmholtz and his wife suffered a similar loss to ourselves in the death of their eldest son. Robert von Helmholtz was from birth a cripple, and it was only by the very greatest care and by the most rigid surgical and medical treatment that he survived his childhood. He became, however, a distinguished mathematician; indeed I have heard his father say that he considered his son's mathematical brain superior to his own, and if his life had been spared he too would have done great things.

Full of honours and esteemed by the whole world, Helmholtz breathed his last on September 8th, 1894. An excellent likeness of Helmholtz faces this page.

I first met the eminent Belgian chemist Stas at Heidelberg, where he had come on a visit to Bunsen. I afterwards called upon him several times at his laboratory in Brussels, and also met him in Paris more than once. He was a very small, refined, delicate man. "Ah, *mon ami*," he used to say, "*je suis très-malade.*" His experimental work, as all chemists know, was the acme of accuracy, and only those who have endeavoured to follow in his footsteps can form a conception of the labour he bestowed upon his atomic weight determinations. It is interesting to remember that whilst Stas's classical researches gave to chemists the proof that Prout's law does not hold good, his earlier work with Dumas was undertaken with the view of ascertaining its truth. He was far from being a rich man, and was held in high esteem in his own country as well as by chemists all the world over. When I visited him in Brussels he resided in a small house

which he had almost entirely given up to his chemical work. He was a bachelor, and lived entirely for science. There is an interesting *éloge* of Stas in the *Mémoires* of the French Academy, and also in the *Series of Memorial Lectures of the Chemical Society* by Professor J. W. Mallet, of Virginia, in 1892. He was a grand example of unselfish devotion to purely scientific work, and all who knew him must have recognised his charming simplicity of character, his affectionate disposition, and his unostentatious life.[1]

Among the most distinguished and gifted of Bunsen's friends was Hermann Kopp. His was a singular personality and in some respects the ideal type of the old German professor. His fame will rest upon his work as an historian rather than as an experimentalist, and his books on the history of chemistry will always hold a high place in the literature of the science.

It was amusing to see Kopp, who was a very small man, walking down the Anlage with his friend—I almost would have said protector—Bunsen, for the small person trotting by the side of his tall and dignified companion reminded one of Landseer's picture of "Dignity and Impudence," though this latter term is scarcely fitting, for Kopp was one of the most modest of men though bubbling over with humour, often with more than a touch of pathos, and crammed full of knowledge.

Apropos of this friendship I am reminded of a grim joke played upon a younger colleague by Bunsen, who in answer to a question remarked: "Yes, a

[1] An interesting experimental criticism of Stas's atomic weight determinations has recently been made by Theodore Richards, of Harvard. He has shown, by methods which rival those of Stas in care and accuracy, that the Belgian chemist was not infallible, and he has pointed out sources of error in Stas's work. *Humanum est errare.*

little chemist of the name of Kopp used to live here. I knew him well for thirty years, but I never understood a word he said." Kopp talked the Hanau dialect of German, Bunsen pure Hanoverian.

My friend Thorpe has done full justice to Kopp's memory in his lecture before the Chemical Society. Several of Kopp's letters lie beside me, of which the following indicates his humour and kind heart, and illustrates his intimate relations with Bunsen, to whose Jubilee it refers.

HEIDELBERG, *Jan. 9th*, 1882.

HONOURED FRIEND,

At present I am working very hard. For some time I was not at all well, but now I am all right again.

We really expected you here for Bunsen's Jubilee. B. has hidden himself with a few chosen friends at Zugenheim in the Bergstrasse; in case you came I had written where we were to be found, in a note which my wife was keeping for you. B. bore the unavoidable with dignity and not without pleasure. He is very well and happy, suffers slightly from chronic bronchial-catarrh, grumbles a great deal, and is therefore thoroughly normal. He sends you hearty greeting; that is to say, he and I have joint authority to do this to mutual absent friends (when I was with him this afternoon as usual, I did not know that I should be writing to you, but I find I have half-an-hour to spare before midnight). He is thinking of going to Italy in the Easter holidays with Quincke. I shall stay here this time and work.

But now good-night. My best wishes to you and yours for the newly-started year.

Your devoted,

HERMANN KOPP.

My knowledge of the Germans and Germany has led me to love the Fatherland, and, I venture to think, to understand as well as to respect and admire the nation. As to any feelings antagonistic to England and the English existing in the minds of the many Germans with whom I became intimate I never found

a trace, for Treitschke I did not know. All with whom I ever came in contact expressed a feeling that England was the old home of freedom, that she had led the van in securing that freedom by gradual and peaceable measures, and, in short, that the path in which the Englishman trod was that in which they wished to follow. "We cannot," my friends said to me, "express our opinion on political matters with the freedom to which you in England are accustomed. How indeed can this be otherwise, when we are governed by an autocratic power which believes in the divine right of kings, and have to submit to a condition of things in which summary punishment for 'Majestätsbeleidigung' is possible?"

It is, however, necessary to remember that a change which may indeed be said to be revolutionary has occurred in Germany. When I first went there, now more than fifty years ago, the population of what subsequently constituted the Empire was under forty millions; at the present time it numbers over sixty. In the second place, half a century ago, oversea commerce and manufacturing industry (Welthandel), such as we in England have enjoyed for generations, was practically non-existent. There was no means of livelihood for the increasing population but agriculture or manual industry (Handarbeit); consequently millions of stalwart men and women of Teutonic blood found their way to the New World, where free scope for employment and improvement lay open to them. Their children, however, soon ceased to be Germans; they no longer looked back on the Fatherland as their home, but threw themselves with ardour into the lap of the Republic, and thus ceased to give power and strength to their old nationality. How different is the present condition of things! The unification of

Germany not only made her great politically, but by fostering her commerce and industry made her a formidable rival to our trade. This being the state of the case, can one wonder that their rulers should seek in other countries an outlet for their teeming population and for their increasing commerce, countries in which the future populations would look back to the "Vaterland" with similar feelings of loyalty and love to those with which our colonists regard the "Mother Country." Can one marvel that they see with envious eyes the steps which we English have taken to secure for ourselves in our lands beyond the sea that for which they so ardently long?

Whether the expressed determination of Germany to become a first-class sea-power may be intended to wrest from us some of our possessions, or whether it is for the simple purpose of protecting their trade, we cannot tell. The mere chance of the first of these happening is sufficiently serious to warrant our determination that, come what may, the English sea-power *must* remain supreme.

At any rate all well-wishers of peace and progress in both countries must deplore the continual attacks made by certain organs of an irresponsible Press on both sides on the good feeling which ought on all hands to prevail. It would be an outrage to civilisation if two countries so closely allied in blood and intellectual development should ever come to blows.

Bunsen, Kirchhoff and Roscoe, Manchester, 1862

Robert W. Bunsen

Hermann von Helmholtz