laboratory on the spectrum of oxygen, I took the opportunity of placing a diamond inside a platinum spiral in an oxygen vacuum, and raising the spiral to a red heat by means of an electric current. The characteristic spectrum of an oxygen compound of carbon at once appeared, leaving no doubt as to the nature of diamond.

The examination for the doctor's degree at Heidelberg in those days was a purely oral one. The candidate was, in addition, supposed to send in a dissertation, but if this was not ready at the time of the *viva voce*, his degree was conferred on the latter alone, subject to the condition that he deposited a sum of money, which, so far as I recollect, amounted to 10*l*. This was returned if the dissertation was sent in and approved within one year. Three subjects had to be chosen; for example, physics, mathematics, and chemistry, of which one formed the principal and took up an hour. For the two others, half an hour was considered to be sufficient. The candidate, when ready, gave notice to the proper authority, and was in due course summoned to present himself on a certain day at seven or eight o'clock in the evening. No account was taken of attendances or period of study. Kirchhoff had the reputation of being a very strict examiner. When at the beginning of the year which I intended to spend at Heidelberg, I asked him how far I was expected to know the more mathematical branches of the subject, the only answer I got was: "I shall examine you in physics." All professors of the faculty received a fee for being present at the examinations, and the faculty of philosophy included all branches of arts as well as of science: this naturally secured a good attendance.

During my visit to Königsberger, the examiner in mathematics, he told me that Kirchhoff was very fond of asking questions about the potential. This reassured me, as I felt pretty safe in that subject, but it turned out that the examination was all on optics. The candidate sat at a long table, surrounded by about twelve severe-looking individuals, most of whom were perfectly ignorant of scientific subjects. As I had not passed the "Abiturienten Examen," which is the school-

leaving test, I had to submit to an additional examination in Latin; but the examiner told me, during my visit to him, that he would pass me however badly I did, and indicated the particular book in Cæsar's "De Bello Gallico" out of which he would ask me to translate a passage. I have a vivid memory of the mournful shaking of heads that went round the table when I translated "frumentum" with "Korn," which in German means "rye," instead of with the proper word which is "Getreide." An hour's *viva voce* can, of course, cover a good deal of ground, for, as soon as the examiner is satisfied that the candidate can answer a question satisfactorily, he at once passes on to another. After the first hour, a quarter of an hour was spent on light refreshments consisting of wine and cakes, and then the examination in the two secondary subjects began. Finally, the candidate was asked to withdraw, and after a few minutes' interval the result was announced to him. If successful, he was summoned to present himself to the Pro-rector next day. The degree was actually conferred after he had delivered an oath in Latin promising many things, one being that he would not take a degree at another German university.

All through the examination it appeared to me that the examiners rather took the part of advocates of the candidates against the gallery of dummy professors who were paid to be present. When I got into a muddle with Kirchhoff over a question involving the wave surface and he had not spotted my mistake, he only said, "We both have been rather stupid over this," and then started another subject. When I could not answer one of Königsberger's questions he said: "There is no need for you to know this; I only asked you on the chance." As a matter of fact, I did know it, but failed to recognise the German expression which he used.

While I was considering the subject of my promised dissertation, I happened to meet the chief librarian of the university, who expressed the hope that I would default, for the reason that the forfeited deposits became the property of the University Library, which depended on this form of revenue.

Obituary.

DR. G. D. LIVEING, F.R.S.

BY the death of Dr. George Downing Liveing shortly after his ninety-seventh birthday, the University of Cambridge has lost the last of that small band of men who some sixty years ago set on foot the movement which proved the foundation of the present science school in that University. He was the eldest son of Edward Liveing, of Nayland, Suffolk; entering at St. John's College, Cambridge, in 1847, he was classed as eleventh wrangler in 1850, and as the first among the six who took the Natural Sciences Tripos in 1851, the year of its creation. After a short period of work under Rammelsberg in Berlin, he became a fellow and lecturer at St. John's College in 1853. In 1860 he married Catherine, daughter of the Rev. R. Ingram, of Little Ellingham, Norfolk, and thus automatically vacated his College fellowship in accordance with the old University statutes; in the same year he became professor of chemistry in the Military College at Sand-

hurst, but continued to teach in the St. John's Laboratory.

The Rev. James Cumming, F.R.S., occupied the chair of Chemistry from 1815 to 1861, and Liveing, who had acted as deputy during the last two years of Prof. Cumming's life, was elected into the chair in the latter year. Liveing retired from the professorship in 1908; the University then conferred upon him the honorary degree of Sc.D. and appointed him an emeritus professor. He had been a professorial fellow of his College since 1880 and was elected into a fellowship again in 1908; in 1911 he became president of St. John's College. For many years he held the responsible and confidential office of Chancellor's secretary, an honorary official whose duty consisted in keeping the Chancellor of the University informed on all material happenings. In addition he served for long as a Borough and County Justice of the Peace, and was punctilious in the performance of his magisterial duties.

On his return from Germany in 1852, Liveing conceived the idea of providing instruction in practical chemistry for the medical students; no chemical laboratory existed in the University and one was equipped in a cottage on the west side of Corn Exchange Street, the fittings being improvised and oil and spirit lamps being used in default of gas. St. John's shortly afterwards built a small laboratory for Liveing, and this he used until long after he became professor in 1861. By this latter date, and largely as a result of the insistence of such progressive spirits as Liveing, the University had decided to build science laboratories; but the University was poverty-stricken, and for this and other reasons the oldest part of the present chemical laboratory was not built on the site of the old Botanic Garden until 1888. The difficulties which Liveing had to surmount in inaugurating a chemical school in Cambridge would have disheartened a man of less determination. His stipend was 100*l.* per annum, paid by the Government and subject to the deduction of Treasury fees amounting to four guineas. As he has himself said, men in those early days had to devote their means as well as their wits to the service of the University. Until his retirement in 1908, Liveing financed the chemical laboratory as a private venture, and he informed me that he declined to submit his accounts, when challenged in later years by the suggestion that he had been drawing a large revenue, because he was ashamed to disclose to his colleagues how large a sum he had thus contributed from his own resources.

Prof. Liveing lectured on heat as well as on chemistry, but in 1871 James Clerk Maxwell was appointed to the Cavendish professorship of experimental physics, a new chair established largely by the exercise of Liveing's influence. Maxwell commenced to deliver the lectures on heat in the chemical lecture-room in October 1871. Later, Liveing espoused the cause of other new subjects in Cambridge; thus, he housed the beginnings of the present flourishing school of agriculture in his own laboratory, and protected and encouraged it until it became independent under the auspices of the Drapers' Company. In a similar way he devoted his energies and money to the establishment of the Cavendish College, an institution for the accommodation of impecunious students. This enterprise soon stopped for lack of funds, and the building is now the Homerton Training College for teachers.

Prof. Liveing was elected into the Royal Society in 1878, and in 1901 received the Davy medal for his spectroscopic researches—"one of the most valuable contributions to this department of chemical physics yet made by British workers." He joined the Chemical Society in 1853, two years before Roscoe, and shortly after his first paper appeared—"On the transmutation of the elements"—in the "Cambridge Essays," first series, for 1855; this little note is characteristic in its breadth of knowledge, its elegance in phrasing, and its economy of words. A few short papers on geological and minor chemical subjects followed, and in 1878 began the great series of memoirs on spectroscopy in conjunction with the late Sir James Dewar, who had been appointed Jacksonian professor of natural philosophy in 1875. The close and intimate friendship which existed between Dewar and Liveing was very striking; both were men of strong personality, but no

two men could have presented a greater contrast in outlook, tastes and all essential characteristics. Yet each held the other in profound esteem, and neither ever said a word in criticism of his colleague; without this absolute loyalty, the happy collaboration of Liveing and Dewar could not have persisted for nearly fifty years.

Liveing's scientific eminence will repose on these joint spectroscopic papers; the skill which he displayed in the development of experimental methods and his infinite patience as an observer resulted in the collection of an enormous mass of accurate data concerning the spectra of the elements which is still in course of interpretation. During his latter years Dr. Liveing occupied himself with the publication in book form of these researches; the "Collected Papers on Spectroscopy," by Dewar and Liveing, was issued by the University Press in 1915. He read his last paper, entitled "The Recuperation of Energy in the Universe," before the Cambridge Philosophical Society on May 7, 1923, and was engaged on experimental work connected with certain ideas put forward in that paper until but a few weeks before his death.

It is difficult to appraise the achievements of one, just passed away, who had left his student days behind him before Frankland had stated the doctrine of valency and before Kekulé had devised the structural formulæ of the chemist. Liveing had been the personal friend of Dr. Whewell, the great Master of Trinity, W. H. Miller, the founder of our present system of crystallographic nomenclature, Adam Sedgwick, Sir Joseph Hooker, Michael Foster, Sir Gabriel Stokes, Sir George Airy, de Morgan and Charles Darwin; he had studied under Rammelsberg, Mitscherlich, Rose and Magnus. He once mentioned to me that he and Hooker, after some preliminary discussion, walked over to see Darwin for the purpose of hastening the publication of the "Origin of Species," which appeared in 1859. In his conversation, always sprightly and vivacious, he seemed often trying to translate our later knowledge into terms of the science of seventy years ago; as befitted one who belonged to the age when the collection of facts was the main objective of science, he was apprehensive as concerned the vast theoretical flights of modern physics and chemistry. Indeed, in his presidential address to Section B of the British Association in 1882, he expressed his distrust of the graphic formulæ of the organic chemist in terms which must be considered as vigorous, coming from one temperamentally so cautious in judgment and so moderate in expression. In talking with Liveing and hearing his statement of long obsolete chemical views,

"Told, when the man was no more than a voice
In the white winter of his age, to those
With whom he dwelt, new faces, other minds,"

one began to realise the difference between the science of seventy years ago and that of to-day, and to speculate as to what our survivors seventy years hence will think of the science of the future. At the same time, and although an authority on the older chemical knowledge, Liveing always maintained an excellent appreciation of recent progress.

Like many other men of robust habit and great vitality, Liveing found it difficult to understand why

his contemporaries dropped out and passed away; declining health seemed to him as due to lack of resolution. He was an enthusiastic gardener, and when well past his ninetieth birthday engaged in all the manual toil incidental to the care of a large garden; after this work had become too heavy he took his exercise by walking, and, in fact, his last illness resulted from a collision with a cyclist. His memory of long-past events was remarkably clear until quite recently, but he sometimes forgot that others could not reach so far back into the past; a few months ago, whilst still in full mental vigour, he expressed surprise that I had not noticed the splendour of Donati's comet—in 1858.

Liveing shirked publicity and rarely spoke in the Senate House because, as he said, he feared being betrayed by provocation into expressing his views—formed with care and then held tenaciously—in terms which might flavour of exaggeration. But whilst others wrangled, Liveing worked, and he will be remembered as the last of that small band of Victorians who possessed themselves of a secluded and conservative institution with splendid traditions and passed it to their successors as a great modern University. A further reason for the rarity of his public utterances lay in the meticulous conscientiousness with which he carried out any duty undertaken; he attended every meeting of the numerous committees and councils of which he was a member, and the sheer labour which he devoted to the study of the questions concerned left him with little leisure or desire to influence others by the spoken word. But the counsels of one so wise, so prudent and so experienced were often sought and were always given in careful and measured terms. With the death of Prof. Liveing, the University has lost one of its most devoted servants, science has lost a pioneer whose early work will long serve as a starting-point for fresh advances, and a great gentleman has passed away.

W. J. POPE.

MR. W. WHITAKER, F.R.S.

THE death of William Whitaker on January 15, though for some weeks it had been clearly imminent, will be felt none the less as a deep personal bereavement by his many friends. The picturesque figure so familiar at the meetings of the British Association, the alertness in body and mind, even after fourscore years and more had laid their burden upon him, but, above all, the geniality which endeared him to all he met, will long be remembered. As a geologist he was a pioneer in the elucidation of the Tertiary strata and the superficial deposits of the south and south-east of England, second only to Prestwick in that branch of the science.

Born in London on May 4, 1836, Whitaker was educated at St. Albans Grammar School and University College, London. At the age of twenty-one he was appointed to the Geological Survey, and continued in that service until 1896. His work lay almost wholly in the London Basin and in the neighbouring counties. The original one-inch geological maps were largely the work of his hands, but he was indefatigable also in collecting records of artificial sections, wells, boreholes, and the other openings which abound in and around London. His labours culminated in the

production of the Geological Survey Memoirs on "The London Basin," "The Geology of London and Part of the Thames Valley," and other smaller works. These volumes form standard works of reference and provide the basis on which much of the later literature is founded.

Among other records collected by Whitaker were those relating to the first deep borings that reached Palæozoic rocks under the Tertiary and Secondary strata of the south of England. By their aid he was enabled to trace variations in the development of these strata and to sketch broadly the form of the Palæozoic floor and the distribution of the rocks forming it. The possible existence and situation of concealed coal-fields had come up for consideration, and so long ago as 1889 he wrote "that Coal Measures are likely to occur somewhere along the line of the Thames Valley, or in neighbouring tracts. . . . It is rash to attempt to foretell the future; but it seems to me that the day will come when coal will be worked in the south-east of England" ("Geology of London and Part of the Thames Valley," p. 46).

Whitaker retired from his official post at the age of sixty, in order to pursue economic geology. As a consulting geologist on sanitation generally, and on questions of water-supply especially, he attained a high reputation. But he still took pleasure in rendering service to the Geological Survey. A long series of memoirs on county water supplies from underground sources testifies to the diligence with which he collected records of wells and springs, and to the skill with which he interpreted them. This work he continued almost up to the last.

The history of the literature of geology occupied much of Whitaker's spare time. For some years he made "The Geological Record" his especial care, and he also compiled many lists of geological books and papers relating to counties, a task that might have proved tedious to one of less pronounced bibliographical tastes. Though much of his work was of this more or less statistical character, there stands to his credit a great record of original research. In addition to the many official memoirs of which he was author or part-author, his papers on Subaerial Denudation, on the Chesil Beach, and on Water Supply from the Chalk may be selected for mention. He was not given, however, to theorising and was never drawn into controversy.

The high esteem in which Whitaker was held by his fellow-workers is shown by the offices he was called upon to fill and the honours he received. Elected to the Geological Society in 1859, he served on the Council in 1873 and many years after, as president in 1898-1900, and as vice-president, 1901-2. In 1886 he was awarded the Murchison Medal, and in 1906 was the second recipient of the lately founded Prestwick Medal, a particularly appropriate recognition of his work in the field in which the founder of the medal had laboured. In 1923 he received the Wollaston Medal, the blue ribbon of British geology. He was elected to the Royal Society in 1887, and served on the Council in 1907-9. He presided over Section C of the British Association at Ipswich in 1895 and gave an illuminating address on the underground geology of that part of England. He was president also of the