Alexander Crum Brown, M.D., D.Sc., LL.D., F.R.S. By Professor Sir James Walker, F.R.S.

(Read November 5, 1923.)

The death of Alexander Crum Brown removes the last of those who played a part in the reshaping of organic chemistry in the early sixties. His main scientific work was done while he was yet a young man, and much of it is now forgotten or only vaguely remembered. Had he possessed a spark of worldly ambition his name would occupy a more prominent position in the history of science than to-day it does, for in actual achievement he is worthy to rank with Joseph Black, his great predecessor in the Edinburgh Chair.

Crum Brown was born in Edinburgh on 26th March 1838, and came of a long line of distinguished divines and theologians, his father being Dr John Brown (1784–1858), minister of Broughton Place United Presbyterian Church. On his mother's side he was descended from Ebenezer Erskine (1680–1754), founder of the Scottish Secession Church. Dr John Brown was twice married. His son by the first marriage was John Brown, M.D. (1810–1882), well known as an Edinburgh physician, but who earned a wider fame as the author of *Rab and his Friends*, *Horæ Subsecivæ*, and other literary essays. Crum Brown, the only son of the second marriage, was named after his maternal grandfather, Alexander Crum of Thornliebank, a merchant and manufacturer of Glasgow. His mother's brother, Walter Crum, F.R.S. (1796–1867), was a chemist of note, and it is probably due to the influence of this uncle that Crum Brown's thoughts were specially directed to chemistry amongst the various subjects of his university studies.

Crum Brown was a precocious child and always busy with models and inventions. Before he went to school he had made a practical machine for weaving cloth, an early indication of his life-long interest in knots and complicated systems of knitting. His education was received in the Royal High School, Edinburgh, where he spent five years, followed by one year at Mill Hill School. In 1854 he entered the University of Edinburgh as a student, first of Arts and then of Medicine. He was gold medallist in the classes of Chemistry and Natural Philosophy and graduated as M.A. in 1858. Continuing his medical studies he received the degree of M.D.

in 1861. During the same time he read for the science degree in London University, and in 1862 he had the distinction of being the first candidate on whom the Doctorate of Science of the University of London was conferred. After his graduation as Doctor of Medicine in Edinburgh he pursued the study of chemistry in Germany, first under Bunsen at Heidelberg, and then at Marburg under Kolbe.

In 1863 he was licensed as an Extra-academical Lecturer in Chemistry by the University of Edinburgh. His classes were small—sometimes the total membership was only two—so that he was left ample leisure for research. In 1869 he succeeded Lyon Playfair in the Chair of Chemistry at the University and held office till his retirement in 1908.

Crum Brown's scientific work bears a marked individual stamp. His mind was essentially philosophic and speculative, and he was specially interested in symbolic representation, as is manifest in his thesis for the M.D. degree, presented at the age of twenty-three. This was not a commonplace report of cases, but was entitled "On the Theory of Chemical Combination," and showed him to be a pioneer in scientific thought. When he took the University course in chemistry under William Gregory there was no laboratory in which practical work could be carried out, and a glance at Gregory's *Hand-book of Organic Chemistry* of the date (1856) shows how small a part theoretical considerations then played in the presentation of the science. Lyon Playfair had succeeded Gregory in 1858, and within a year or two had created a useful teaching laboratory, but that even he was far from being on the scientific level of the young medical student is evidenced by the cold reception given to Crum Brown's thesis in 1861. It was judged as "worthy to compete" for the Dissertation Prizes, but did not receive one, although no less than sixteen awards were made. In this thesis he expresses his purpose to sketch the history of the law of Equivalence or Substitution, and the law of Polarity, "to discuss the bearing of recent discoveries on them; and to endeavour to determine what is the form in which they may best be expressed, so as to include all the facts, and be, as nearly as possible, a strict generalisation from them." In the course of the discussion of types and radicals he evolved a system of graphic formulation in all essentials identical with that in use at the present day. His formulæ were the first to represent clearly and satisfactorily both the valency and the linking of atoms in organic compounds. His views of polarity are instructive: "(1) Bodies (*i.e.* radicals, simple and compound) may be arranged with general accuracy in a linear series, the members of which differ from each other in polarity (*i.e.* as being positive or negative), according to their distance from each

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other in the series. The few exceptions to this seem to indicate that there is more than one cause producing the variations in polarity. (2) Bodies preserve their polar properties in combination, and in compound radicals the substitution of one or more negative for one or more positive atoms renders the radical more negative, and *vice versa*." He concludes by saying, "The questions with which we set out [namely, What is the nature of the forces which retain the several molecules or atoms of a compound together? and How may their direction and amount be determined?] are not yet capable of being answered, although a certain amount of progress has been made towards their solution. Chemistry, however, labours, and probably must always labour, under a great disadvantage as compared with most other branches of physics, in so far as the application of mathematical analysis is concerned. The very existence of the atoms, the consideration of which should form the starting-point of such analysis, is hypothetical. Still, it does not seem to me improbable that, by assuming that these atoms exist, and that certain forces act upon them under certain laws, we may be able to form a mathematical theory of chemistry, applicable to all cases of decomposition and recomposition, the truth of whose results shall be independent of the truth of those assumptions by means of which the theory has been formed, just as the truth of the results of the undulatory theory of light is independent of the existence of the luminiferous æther."

In this thesis he displays an insight and a philosophic wideness of vision comparable with that of Archibald Scott Couper, with whose work at that time Crum Brown was unacquainted, although strangely enough in the year 1858 they must have been in the University together, Couper having served as Lyon Playfair's assistant for a few months before the onset of his tragic illness.

In 1864 Crum Brown published in the *Transactions* of the Society * an important paper on the "Theory of Isomeric Compounds," in which, making free use of his graphic formulæ, he discusses the various types of isomerism, paying special attention to that of fumaric and maleïc acids, and, in general, to compounds that are "absolutely isomeric" (*i.e.* which possess the same constitutional formula). He criticises the views of Kekulé and of Butlerow, and concludes, "We thus see that the attempts to apply to the explanation of particular cases the principle of a difference between the equivalents of multequivalent atoms have failed, not . . . from any absurdity in the principle itself, but rather from a want of well-observed facts to guide us in its application."

* *Trans. Roy. Soc. Edin.*, vol. xxiii, p. 707.

In 1866 in continuation of his systematic work he published * a paper "On the Classification of Chemical Substances by means of Generic Radicals." This paper he sent to Frankland, and received from him letters, dated 28th May and 4th June 1866, containing the following extracts, which show the reception accorded to graphic formulæ at that period: "Many thanks for the proof of your very interesting paper on the classification of chemical substances. I am much interested in graphic formulæ and consider that yours have several important advantages over Kekulé's. In my lectures here last autumn I used them throughout the entire course, and with very great advantage, and I have now in the press a little book of *Lecture Notes for Chemical Students* in which they are copiously used." "I am just now endeavouring to get Kolbe to express certain of his fundamental formulæ graphically. We should then understand each other better. There is a good deal of opposition to your formulæ here, but I am convinced that they are destined to introduce much more precision into our notions of chemical compounds. The water-type, after doing good service, is quite worn out."

In 1867 Crum Brown published a paper, "On an Application of Mathematics in Chemistry," which bears a superficial resemblance to Sir Benjamin Brodie's "Calculus of Chemical Operations," but differs from it in method, object, and result. He uses a functional notation to express certain general and serial relations in those cases where the common atomic notation is inconvenient or obscure. In a criticism of Brodie's system in the same year † he upholds the use of atomic and graphic formulæ and says, "While there can be no doubt that *physical* research points to a molecular constitution of matter, it is perfectly indifferent to a *chemist* whether his symbols represent atoms or units; and graphic formulæ could be as useful as they are now, were it conclusively proved that matter is continuous." It is interesting at the present time to note that in considering the (formal) polymerisation of acetylene he arrives by one method of representation at Dewar's formula for benzene and by an alternative method at Kekulé's.

Although Crum Brown apparently never contemplated the practice of medicine, his training as a medical student gave him an interest in physiology and pharmacology which led him to collaborate during 1867–8 with T. R. Fraser, a distinguished medical graduate a few years younger than himself, in a pioneering investigation of fundamental importance on the connection between chemical constitution and physiological action.‡ Their

* *Trans. Roy. Soc. Edin.*, vol. xxiv, p. 331.
† *Phil. Mag.*, 4th ser., vol. xxxiv, p. 129.
‡ *Trans. Roy. Soc. Edin.*, vol. xxv, pp. 151 and 693.

method "consists in performing upon a substance a chemical operation which shall introduce a known change into its constitution, and then examining and comparing the physiological action of the substance before and after the change." The operation considered was the addition of ethyl iodide to various alkaloids, the iodides (and the corresponding sulphates) thus obtained being compared with the hydrochlorides of the original alkaloids. Striking regularities were observed, amongst others "that when a nitrile [tertiary] base possesses a strychnia-like action, the salts of the corresponding ammonium [quaternary] bases have an action identical with curare."

Crum Brown's name was now well known and in his application for the Edinburgh Chair in 1869 he received the support of nearly all the prominent chemists of this country. Amongst the names of Continental chemists who bore testimony to his ability may be noted those of Baeyer, Beilstein, Bunsen, Butlerow, Cahours, Erlenmeyer, Hofmann, Kolbe, Volhard, and Wöhler.

For some time after his University appointment he published little, but in 1873 he began a series of investigations of the organic sulphur compounds,* particularly derivatives of trimethyl-sulphine, which occupied him for several years, after which there was an intermission in his scientific output. In 1890 he entered a new period of chemical activity. A theoretical paper on the relation of optical activity to the character of the radicals united to the asymmetric carbon atom † was published simultaneously with Guye's communication on the same subject. Crum Brown's treatment is more general than Guye's, postulating a function κ for each radical, and giving examples of the methods to be employed for its determination: "Of course we cannot as yet even approximate to a formula for the amount of rotation in terms of the four κ's and temperature, but as the rotation becomes zero when any two κ's become equal we may presume that it contains the product of the differences of the κ's. The first thing to be done with this speculation is to find whether κ is really a function of the composition and constitution of the radical and of the temperature of the substance, or varies with the character of the other three radicals." Here once more we have the characteristic breadth of view and clearness of statement. About the same time began the series of researches on the synthesis of bibasic acids by the electrolysis of ester-salts.‡ In 1892 he published in conjunction with John Gibson the well-known rule for determining

* Crum Brown and Letts, *Trans. Roy. Soc. Edin.*, vol. xxviii, p. 571, and various papers in *Proc. Roy. Soc. Edin.*

† *Proc. Roy. Soc. Edin.*, vol. xvii, p. 181.

‡ Crum Brown and Walker, *Trans. Roy. Soc. Edin.*, vol. xxxvi, p. 211; vol. xxxvii, p. 361.

the position in the benzene nucleus taken up by an entering radical with respect to one already present.*

The then new physico-chemical theories of osmotic pressure and of electrolytic dissociation roused his interest, and, while he retained an open mind on the subject, he gradually became convinced of their essential validity. He did much to place them clearly before his students and published experiments illustrating the utility of both theories.†

No mention has been made of minor chemical papers dealing with practical matters, nor of the numerous and interesting addresses which he from time to time delivered. Amongst them a very clear account of the rusting of iron may be noted.‡ His view of the position of chemistry in the domain of the mathematical-physical sciences is stated in his presidential address to the Chemical Section of the British Association in 1874: "One thing we can distinctly see—we are struggling towards a theory of Chemistry. Such a theory we do not possess. What we are sometimes pleased to dignify with that name is a collection of generalisations of various degrees of imperfection. We cannot attain to a real theory of Chemistry until we are able to connect the science by some hypothesis with the general theory of Dynamics . . . Chemistry will then become a branch of Applied Mathematics, but it will not cease to be an experimental science. Mathematics may enable us retrospectively to justify results obtained by experiment, may point out useful lines of research, and even sometimes predict entirely novel discoveries, but will not revolutionise our laboratories. Mathematical will not replace Chemical analysis." In his presidential address to the Chemical Society in 1892 he exhorts the young chemist to study mathematics. "The most perfect dynamical explanation of chemical constitution and chemical change will not enable us to dispense with the old processes of analysis and preparation. The chemist will still be the man trained in the chemical laboratory, and all the mechanical parts of the work will be done by him. But unless he learns the language of the empire [mathematics], he will become a provincial, and the higher branches of chemical work, those which require reason as well as skill, will gradually pass out of his hands"—a prophetic utterance.

Crum Brown had forty years ago very modern views as to crystal structure (Art. "Molecule," *Encyclopædia Britannica*, 9th ed., 1883): "It is perhaps scarcely correct to speak of a molecular structure of [crystalline] solids at all. Solids are no doubt composed of atoms and those atoms

* *Chem. Soc. Trans.*, vol. lxi, p. 367.

† *Proc. Roy. Soc. Edin.*, vol. xxi, p. 57; vol. xxii, p. 439.

‡ *Jour. Iron and Steel Inst.*, 1888, p. 129.

are evidently arranged in what may be called a tactical order. When the solid is fused or dissolved or volatilised, it breaks into molecules, each repetition of the pattern being ready to become an independent thing under favourable circumstances. It may be urged that the cleavage of crystals indicates that they possess a molecular structure, but a tactical or pattern-like arrangement of atoms may easily be supposed to present planes of easier separation without the assumption of really independent molecules." Many years before the work of Laue or Bragg, Crum Brown in conversation with the writer mentioned that he had constructed a model of the structure of sodium chloride, each chlorine atom having six equidistant sodium neighbours and each sodium atom six equidistant chlorine neighbours, the type of structure being that now attributed to potassium chloride.

Crum Brown never lost his interest in physiology, and at various times he made valuable contributions to that science. One of these was a study of the sense of rotation and the function of the semi-circular canals of the internal ear * (1873–4). His work was contemporaneous with that of Mach and Breuer, but his explanation went beyond theirs, suggesting the function of the ampullæ and showing how complete perception of rotation could be secured by the actual arrangement of the canals in the two ears. The relation between the movements of the eyes and the movements of the head also engaged his attention, and on this subject he wrote several papers. The analysis of vowel sounds too at one time interested him, and he invented a "talking bottle" which, when blown, emitted vowel sounds varying with the stopping of the holes with which it was provided. The only medical case which he ever described was one of dyspeptic optical vertigo—his own. He details the symptoms with minuteness and gusto, makes careful observations of his sensations, carries out experiments while in bed and during convalescence, and draws appropriate conclusions—both physiological and psychological.

Several published papers show his serious attention to certain branches of mathematics, for example, one on interlacing surfaces,† and another on the partition of a parallelepiped into tetrahedra, the corners of which coincide with the corners of the parallelepiped.‡ A favourite hobby was the practical construction of three-dimensional models, both crystallographic and mathematical, a glue-pot on the hob and a plentiful stock of cardboard being recognised features of his retiring-room in the University. In literature his reading was extensive, and his knowledge of languages,

* *Proc. Roy. Soc. Edin.*, vol. viii, pp. 255 and 370; vol. xv, p. 149.
† *Ibid.*, vol. xiii, p. 382.
‡ *Trans. Roy. Soc. Edin.*, vol. xxxvii, p. 711.

ancient and modern, was altogether exceptional. His keenness for symbols came out in his study of alphabets and, generally, of systems of writing.

A man of his great and varied gifts could scarcely prove other than a stimulating teacher, although to the average elementary student his lectures were rather a trial. A former pupil of his writes, "Briskly entering the class-room, he began at once in rapid phrasing to describe the properties of a chemical substance or the intricacies of a chemical process. Chemical formulæ grew like magic on the black-board. The casual and limp-minded listener found Crum Brown's quick vivid style much too strenuous; but the student who really wished to learn, and had ear and eye in well-trained attention, could not fail to experience keen intellectual delight from the masterly manner in which the whole subject was presented." His lectures on organic chemistry to advanced students were revelations of the working of scientific method. He selected a few topics and dealt with them in full detail, never letting the student lose sight of the end to which the researches he described were directed, nor of the logical thread running through them. He delighted in analogies and parables, and exercised the greatest ingenuity in seeking from familiar life parallels to the scientific lesson which he wished to inculcate. A characteristic example may be found in his Presidential Address to the Chemical Society * where he likens the behaviour of a quantity of salt in solution to the doings of a cattle-holding community.

His turn for business was almost as notable as his talent for speculative thought. Before a Faculty of Science was established in the University he long acted as convener of the Science Committee of the Senatus and directed the course of students desirous to receive a scientific training. For many years too he was a member of the University Court, taking a prominent part in the business administration of the University. Outside the University, his Church and the Royal Society of Edinburgh claimed his chief practical interests. In Synod and Assembly he was eagerly listened to for the pith and wisdom of his utterances. His service on the Council of the Royal Society of Edinburgh extended to forty-four years in all, during twenty-six of which he acted as one of the secretaries, and for six as a vice-president. The Society awarded him the Makdougall Brisbane Prize for the period 1866-8 (in conjunction with Dr T. R. Fraser), and the Keith Prize for the period 1873–5. His loyalty to the Society, in whose *Transactions* and *Proceedings* he published nearly all his researches, had no doubt something to do with the scant recognition of his work, their circulation amongst chemists being very limited. He

* *Chem. Soc. Trans.*, vol. lxi, p. 481.

was elected a Fellow of the Royal Society in 1879, and had honorary degrees conferred on him by all four Scottish Universities. He occupied the Presidential Chair of the Chemistry Section of the British Association in 1874 and of the Chemical Society in 1891–3.

Crum Brown presented the refreshing and fascinating contrast of a simple character combined with a brilliant and subtle intellect. He possessed a keen wit, tempered by the most delightful pawky humour: being besides a born raconteur, he shone in social gatherings, especially at his own hospitable table. He was generous and kindly, and his great learning was accompanied by a fine modesty. Though naturally impatient, and though he had counted Clerk Maxwell, Kelvin, and Tait amongst his intimates, he was ready always to listen with sympathy and understanding to the ideas of those who were vastly his intellectual inferiors.

A pair of dark, sparkling, deep-set eyes formed the most striking feature of his appearance, and were a fit index of his vivacious temperament. Though physically not very robust, he spent much of his holiday time in tramping in the Highlands and on the Continent, and was rarely ill. He married early in his professorial life Jane Porter, a daughter of the Rev. James Porter, Drumlee, Co. Down, whose death two years after his retirement from University duties overshadowed the last decade of his life. Failing bodily health confined him to the house, and for over seven years he had most unwillingly to regard himself as an invalid. His mind lost little of its activity. He read much and amused himself with original methods of knitting. He enjoyed conversing with his old friends, and even when increasing weakness made this somewhat of an effort for him, he would still, with an inextinguishable twinkle of the eye, retail some quaint story or interesting reminiscence. He died peacefully on 28th October 1922, leaving to all who knew him a legacy of very pleasant memories.