



G. G. Henderson.

## GEORGE GERALD HENDERSON

1862-1942

IF the story of George Gerald Henderson be told merely as a chronological record there would remain for our successors an imperfect picture of a very remarkable man. He was a Scot, and received his scientific education at the University of Glasgow ; in succession he held a lectureship and two professorships of chemistry in his native city and he died full of years in the land he loved. The story as thus told suggests that his life's work was spent in a limited sphere; but that is true only in a geographical sense, for his influence spread far afield and in his day he was recognized as one of the most prominent figures in British chemistry. It will be generally conceded that the period when the nineteenth century merged into the twentieth was a critical time in the development of science in this country. Opportunities for scientific education were expanding rapidly, facilities for original research were becoming more widely available, and the investigator was no longer a solitary worker. These were profound changes, and no country—least of all a small country such as Scotland, firmly wedded to long-established educational tradition—could take a profitable part in what we must regard as an educational revolution, in the absence of wise scientific leadership. That role was played by G. G. Henderson and he played it supremely well. While it is a pious duty, willingly undertaken, to pay tribute to his life's work, it is difficult for me to speak freely of him as a man, for I was bound to him by ties closer than those which usually link master and disciple. Nearly half a century ago it was my lot to sit each morning in the bleak Chemistry Lecture Theatre of the old Andersonian Institute in Glasgow and thereafter to spend most of the day at toilsome quantitative separations in a depressing laboratory. It is not merely the passage of the years which has softened the memory of many discomforts then endured and has left a permanent impression of happiness; for even as young and callow students we were conscious that we were led by one who, without his seeking, had gained the honour of winning from youth something which approached hero-worship. No doubt we worked enthusiastically at our chemistry because of interest in the subject, but we did so in greater measure to reap the reward of our professor's commendation. He did not attain this position through cultivating the goodwill of students by over-indulgence; indeed the reverse was the case, and, while his words of praise were few, he never shirked the stinging rebuke due to those who failed to give of their best. Instinctively he knew when, where and how to encourage, or, if need be, to blame. I am not alone in looking back to the early days of Henderson's first professorship with more than mere appreciation;



although now a dwindling band, his old students of the 1890's still remember gratefully what they owe to the influence of a great teacher.

The path he had climbed to reach a professor's chair at the early age of thirty was not easy, and his adoption of a scientific career cannot be explained in terms of heredity or environment. Born on 30 January 1862, the second son of a Glasgow merchant, he could claim descent from a long line of Kinross-shire lairds. Church and State had each made their contributions to his inheritance, but no trace is to be found of scientific influences and his early education, pursued at a private school, was based largely on classics and mathematics and followed orthodox lines. Nevertheless, when he entered the University of Glasgow at the impressionable age of fifteen and a half, he broke away from school and family tradition and embarked on the study of science in place of submitting himself to the customary discipline of the liberal arts. Mathematics, physics, chemistry, geology, botany and zoology composed the strenuous curriculum of the period; the course was obviously designed to give a broad scientific education rather than to produce specialists, but Henderson had not reached his twentieth birthday when he graduated B.Sc. 'with Distinction' in chemistry and had published his first paper on the formation of serpentine from dolomite. Reversing the usual order of study he then proceeded to complete the Arts degree, his seven pillars of wisdom being Latin, Greek, English, logic, moral philosophy, mathematics and natural science. In these studies he displayed his versatility and acquired delicate scholarly tastes which never forsook him—there are few professors in our generation who were prizemen in both Greek and chemistry.

He was now firmly pledged to science and he brought to bear on his special study a well-nourished mind. Recognizing that the training in Glasgow was deficient in organic chemistry and in the new physical chemistry, Henderson proceeded to Leipzig, where in successive long vacations he extended his studies and commenced organic research under the direction of Wislicenus. In the leisurely days of last century the long vacation, extending as it did from March to October, was worthy of the name and it was thus possible for young Henderson to divide the academic year into two equal parts. The first half was spent in the University of Glasgow as a lecturer and demonstrator teaching inorganic chemistry and mineralogy, while in the second half he made himself increasingly efficient as a student of organic chemistry in the famous Institute in the Liebigstrasse. The fruits of this strenuous preparation matured rapidly and his subsequent publications on synthetical uses of malonic ester and acetoacetic ester reflected the inspiration of Wislicenus on this zealous pupil. One of these modest papers is worthy of special mention, for, as long ago as 1889, Henderson described the action of chromium oxychloride on pinene and directed attention to the use of a reagent which was destined in his hands to give valuable results in future work. It was appropriate that academic promotion should follow quickly and the opportunity to offer him independent status as a lecturer came in 1889 when he was appointed to Queen Margaret College, Glasgow. In the movement which resulted in the admission of women students to the Scottish



universities, Glasgow played a leading part and at first adopted the policy of providing special classes and a separate college for women. There for three years Henderson developed his teaching powers, and continued, under severe difficulties, his researches on topics in which the influence of Wislicenus, if still discernible, is faint. In 1892 he was called to succeed Dittmar as Freeland Professor of Chemistry in what was then known as the Glasgow and West of Scotland Technical College. The locus of the chair was the Andersonian Institute, a massive building not without a certain architectural dignity but peculiarly unsuitable as a school of experimental sciences. Cramped quarters, and an almost total lack of ventilation were ill-adapted for the complex quantitative analyses which formed the basis of student instruction, but on the other hand the balances and instruments of precision were excellent, and quantitative accuracy was the key-note of the training. The allegiance of chemistry to mineralogy still survived and Henderson wisely made no attempt to interfere with the Dittmar tradition that practice in analysis is the best introduction to chemistry—well-thumbed copies of Fresenius were to be found in most of the benches—but he extended the exercises in organic chemistry, gradually introduced physical chemistry, and in the end provided courses which would be recognized even to-day as highly efficient. At that date there was no examination for entrance to the college, and, in consequence, great variation existed in the quality of the students who for the most part were preparing themselves as analysts or works chemists. This fact placed a heavy burden on the professor, who of necessity had to adapt his lectures to the capacity of his audience and at the same time had to prepare the best of his students for the degree examinations of London University. Henderson accomplished this difficult task with masterly skill. Unlike some of his colleagues in other departments he found no difficulty in maintaining discipline for in his presence the most turbulent students quailed and over-exuberance wilted. Above average height, slim, well-tailored and athletic (reputedly he was the first man to skate from Balloch to Luss when Loch Lomond was frozen in the Great Frost of 1894), he commanded attention from the moment the lecture started. He used few notes, his experiments were performed with dexterity and were arranged with an eye to artistic effect, the blackboard illustrations were elegantly written, and the most complex equations always balanced. Whether or not he had consciously adopted Spurgeon as his model, the fact remains that his opening and closing sentences were always carefully prepared and were calculated to arrest immediate attention and to carry interest forward to the succeeding lecture. It all seemed so natural and spontaneous that it came as a surprise in after years to learn that this smooth technique of teaching was the product of much study and careful practice. Equally it was surprising to realize that the professorial dignity with which he carried himself was a cloak to cover a measure of shyness.

In the laboratory, he gave the impression that the case of each individual student was the professor's special care. Following a time-table, the underlying system of which we never fully discovered, so that his visits came on unexpected and sometimes inconvenient occasions, he made his daily rounds and impressed



on each of us that accurate working can only be conducted on a tidy bench. His own bench certainly conformed to his high standard of neatness and there in his scanty leisure (there were evening classes as well as day classes) he worked on the formation of compounds analagous to tartar emetic. These researches reflect his earlier association with the Medical School at Glasgow, and the influence of van 't Hoff was also apparent in his studies on the optical effect induced in lactic acid by reaction with metallic oxides; but a more striking divergence in research interests was due to his growing friendship with Dr (afterwards Sir George) Beilby. The problem of investigation in which they collaborated had originated in the technical difficulty of finding a metal suitable for conducting a current of ammonia at high temperatures, and the source of the trouble was traced to the alternate formation and decomposition of the corresponding metallic nitride. This led to a general study of nitrides, and the resulting publication is not only a model of its kind but is also a striking example of the labour and ingenuity necessary for the solution of such problems before the adoption of purely physical methods greatly simplified the procedure. Other researches on analytical topics likewise revealed his allegiance to inorganic chemistry, but in 1903 there appeared the first of his papers on the terpenes, a task he never laid down until his research days were done. Of some seventy publications which bear his name, about half are concerned with terpene problems: these papers, to which detailed reference will be made later, appeared in steady succession over a period of thirty years, even at times when he was heavily engaged with other duties.

Despite increasing invasion of his time, Henderson never forsook the research bench and his story provides yet another example of how scientific zeal cannot be extinguished by the exacting claims made on professors who are unfortunate enough to possess a capacity for business affairs coupled with a sense of public duty. 'Never allow yourself to become a committee man' was advice he often gave to his pupils and although he himself broke the rule he did so with full knowledge of the sacrifices involved.

Recognition that the Technical College of Glasgow was worthy of buildings appropriate to its purposes and achievement was slow in maturing, but in the end the idea was magnificently realized and Henderson gave invaluable help in carrying out the great building scheme. But he had not long enjoyed the facilities of his new laboratories when the call came to him in 1919 to return to the University of Glasgow as Regius Professor of Chemistry—his path of progress was cyclic, and so far as the Royal Technical College was concerned, he had 'found Rome brick and left it marble'. His entry into the University Chair coincided with the return of soldier students from the Four Years War, and Henderson brought all his fine qualities of heart and mind to the fulfilment of the duty of mending broken careers. Classrooms were overcrowded; teachers were overworked and students were overstrained; but in the midst of this confusion there was the quiet controlling force of a professor who never seemed to weary and who never lost his cheerful outlook on life. At this period, the claims of other duties were increasing; he acted as Dean of the Faculty of



Science and as an Assessor on the University Court. Outside his university work he had for many years been an active member of the British Association and had worked his way up to the Presidency of Section B, where his address may be regarded as the first serious attempt to trace the effect of the scientific revolution on the early history of chemical industry in Scotland. Similarly, his activity on the Councils of the Society of Chemical Industry and the Institute of Chemistry was recognized by his call to the President's Chair of each of these bodies. There remained one further honour which was his as of right—the Presidency of the Chemical Society—and this came to him in 1931, by which date he had been a Fellow of the Society for forty-six years. The frequent journeys to London imposed a considerable strain on an overworked man of seventy, but there can be no doubt that Henderson greatly enjoyed his tenure of the president's office and he often spoke in terms of sincere appreciation of the way in which everything was done to ease his burden. He presided at meetings with a due sense of the dignity belonging to the leadership of a learned society; his bearing was in no sense austere and he knew how to put new members at their ease, infusing into the most diffident young chemist the spirit of fellowship which is, or ought to be, the essence of a scientific community.

Intermingled with this strenuous programme he gave eight years of earnest thought to the scheme of providing a Chemistry Institute worthy of the University of Glasgow. The large capital sum required was ultimately forthcoming, and Henderson, for the second time in his life, devoted himself to the problems of architectural planning. Only when he felt that the task had reached a stage where final details should be left to his successor did he seek the leisure he had earned so well, and in 1937 he resigned from his Chair.

In his round of ceaseless activities he was sustained by the serene happiness of his home life and the loving care of his wife. In 1895, soon after his appointment to the Freeland Chair, he married his cousin, Agnes Mackenzie Kerr, and for more than forty years she made his life glad, welcoming colleagues and students round the study fire, accompanying her husband on his travels, sharing his interest in music and joining annually in the fishing expeditions to the Outer Hebrides. The fact that they remained childless served to make more active a close companionship which was broken with tragic suddenness. Their intention was to retire to the Isle of Harris, which had been the scene of many a happy fishing holiday and Mrs Henderson was preparing their island home for the arrival of her husband when death overtook her without warning. So it was a tired broken-hearted man who said good-bye to his chemistry and sought consolation in scenes hallowed by precious memories and in the company of simple islanders who made him welcome in their midst. The time of waiting was not long and on 28 September 1942, Henderson passed away, suddenly, as was his desire. It does not need the confirmation of his letters to convince me that many a time in his solitude he looked back with quiet pleasure on the opportunities which had come to him to serve science faithfully and well. Honours were not denied him; he was elected a Fellow of the Royal Society in 1916, received honorary degrees from St Andrews, Glasgow and Belfast, and



was awarded the medal of the Society of Chemical Industry. Despite his inherent modesty these marks of public recognition were welcome to him, but more and more his thoughts turned to his former students and colleagues. There were many of them who had won their way to responsible positions, among them, Professors I. M. Heilbron, A. Robertson, A. R. Todd, W. R. Boyd, M. A. Parker, F. J. Wilson and W. R. Lang. But there is also that wider circle of men and women scattered over the world who are doing good work and doing it all the better through the example he set before them and as a result of the scientific training received at his hands. Science in Scotland is poorer by the passing of George Gerald Henderson; but his work and worth will not be forgotten, and his name will be held in affectionate remembrance in our generation.

J. C. IRVINE

The following account of Henderson's researches on the terpenes has been contributed by Dr J. L. Simonsen, F.R.S., to whom I am much indebted.

J. C. I.

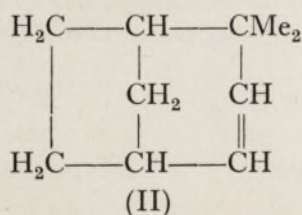
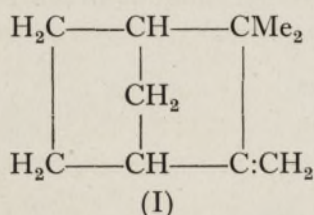
In 1889 in a short paper Henderson reported the results of some preliminary experiments on the oxidation of  $\alpha$ -pinene with chromyl chloride. He returned to this subject some ten years later and thus opened a field of research which was to form the main interest of the Glasgow Laboratories for the next thirty years. When this work was commenced, the chemistry of the terpene hydrocarbons was still in a very confused state and Henderson clearly thought that our knowledge might be advanced by a study of their interaction with some of the less powerful oxidizing agents such as chromyl chloride, hydrogen peroxide and hypochlorous acid.

Étard (*C. R. Acad. Sci. Paris*, **116**, 434 (1893), had observed that  $\alpha$ -pinene and camphene on oxidation with chromyl chloride gave an aldehyde  $C_{10}H_{14}O$ , from which an acid  $C_{10}H_{14}O_2$ , could be prepared whereas according to Bredt and Jagelki (*Liebigs Ann.* **310**, 113 (1899)) camphene gave with this reagent camphenilanaldehyde,  $C_{10}H_{16}O$ , and camphenilanic acid,  $C_{10}H_{16}O_2$ , which isomerized readily to *isocamphenilanic acid*. Although Henderson himself did not investigate the oxidation of camphene with chromyl chloride, as will be seen later he gave considerable attention to the products described by Bredt and Jagelki.

With Gray and Smith (1903) and with Heilbron (1908) he showed that  $\alpha$ -pinene gave on treatment with chromyl chloride in carbon disulphide solution a substance  $C_{10}H_{16}$ ,  $2CrO_2Cl_2$ , decomposed by water to yield an aldehyde,  $C_{10}H_{16}O$ , and a ketone,  $C_9H_{14}O$ , together with a chloro-compound  $C_{10}H_{15}OC1$ . The structure of these degradation products was not elucidated but it is highly improbable that they contain either a pinane or camphane ring structure. Many years later, in collaboration with Chisholm (1924), he found that the ketone was formed also by the oxidation of  $\beta$ -pinene with chromyl chloride,

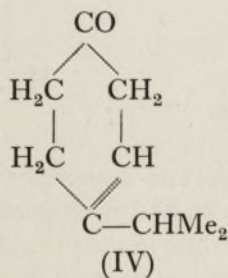
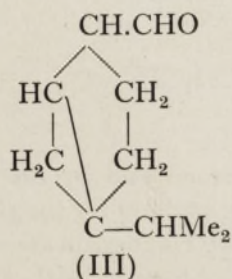


although the other products were different and the only one identified was trans-pinolglycol (Wagner and Slawinski, *Ber. deutsch. chem. Ges.* **32**, 2072 (1899)). The oxidation of bornylene with chromyl chloride (with Heilbron, 1911) proceeded more smoothly yielding a chloro-ketone  $C_{10}H_{15}OC1$ , from which camphoric acid was obtained on oxidation. This chloroketone, since it is not identical with either of the isomeric  $\alpha$ -chlorocamphors, subsequently described by Lowry and Steele (*J. Chem. Soc.* **107**, 1382 (1915)), is probably a chloro*epi*-camphor. Other products of the oxidation were camphenilanaldehyde and *isocamphanil*analdehyde. Henderson and Heilbron during the course of this research studied also the action of nitrous and nitric acids on bornylene. By the action of the former reagent bornylene nitrosite was prepared, and by the action of nitric acid dinitrocamphane was obtained. As a result of this investigation Henderson and Heilbron (1911) were led to discuss in an interesting theoretical paper the structure of camphene for which at that time the formulae (I) and (II) were under consideration.



In this admirable contribution they advanced cogent evidence in support of (I) and they suggested, apparently for the first time, that the abnormal results obtained on the oxidation of camphene with potassium permanganate may have been due to the alkalinity of the solution in which the oxidation was carried out. This suggestion was subsequently confirmed by Langlois (*Ann. Chim.* (ix) **12**, 301 (1919)).

With Robertson and Brown (1922, 1924) the oxidation of sabinene with chromyl chloride was studied and was found to give sabinenaldehyde (III) and  $\Delta^1$ -*isopropylcyclohexen*-4-one (IV).

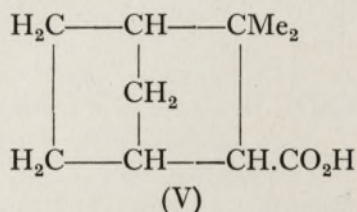


The first action of chromyl chloride on monocyclic terpenes would appear to be their dehydrogenation to *p*-cymene since it was found (1907; with Cameron, 1909), that both limonene and  $\alpha$ -terpinene gave  $\alpha$ -*p*-tolyl-propal-

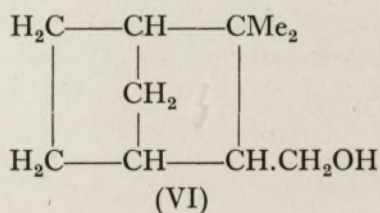


dehyde and *p*-tolyl methyl ketone, products identical with those obtained by the reaction of this reagent and *p*-cymene (Errara, *Gazz. chim. ital.* **19**, 528 (1889); **21**, 76 (1891); Miller and Rohde, *Ber. dtsh. chem. Ges.* **23**, 1070 (1890); **24**, 1356 (1891)).

In another series of papers the oxidation of the dicyclic terpenes  $\alpha$ - and  $\beta$ -pinene, camphene and bornylene with hydrogen peroxide was described (with Sutherland, 1910, 1912, 1914; with Caw, 1913; with Chisholm, 1924). With  $\alpha$ - and  $\beta$ -pinenes only the usual hydration products,  $\alpha$ -terpineol, borneol and fenchyl alcohol were obtained but results of greater interest were observed with camphene and bornylene. Oxidation of camphene resulted in the formation of camphene glycol, camphenilone, *isocamphenilanaldehyde*, an isomeride of camphenilanaldehyde (V) and camphenanic acid. Peculiar interest attaches to this acid, m.p.  $95^\circ$ , since it can be isomerized to *isocamphenanic acid*, m.p.  $74^\circ$ . These two acids are isomeric also with camphenanic acid, m.p.  $65^\circ$  and *isocamphenilanic acid*, m.p.  $118^\circ$ , prepared originally by Bredt and Jagelki (loc. cit.) by the oxidation of camphene with chromyl chloride. Bredt (*Annalen*, **366**, 57 (1909)) assigned to these acids the structure (V)



Henderson and Miss Sutherland studied in great detail the interconversion of these four acids and whilst there can be little doubt that (V) correctly represents camphenilanic and *isocamphenilanic acids* the relationship of these four acids to one another is still obscure since their esters give on reduction the same alcohol, camphenilanol (VI).



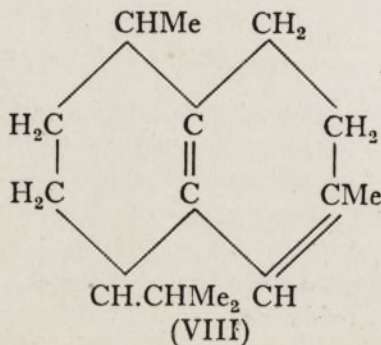
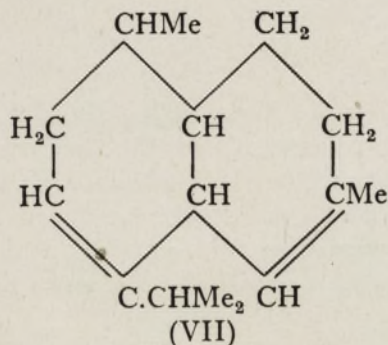
Camphenanic and *isocamphenanic acids* are formed also by the oxidation of bornylene with hydrogen peroxide. A convenient method for the preparation of this hydrocarbon in the pure state was described by Henderson and Caw (1912).

A brief reference may be made also to three papers (with Heilbron and Howie, 1914; with Marsh, 1921; with Kerr, 1924) on the action of hypochlorous acid on  $\alpha$ - and  $\beta$ -pinene and on camphene. With the former hydrocarbons ring fission occurs with the formation of dichlorohydroxymethanes, from camphene a chloro*isoborneol* is obtained.

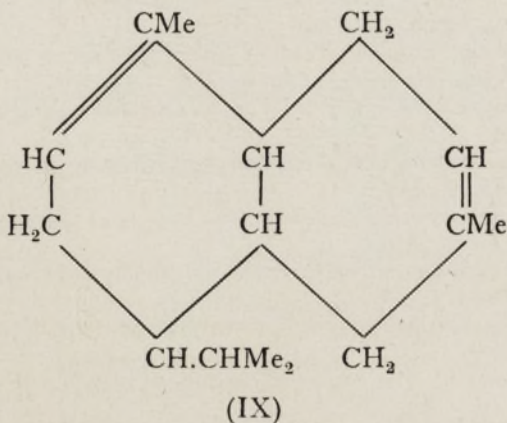


Influenced doubtless by his interest in catalysis, Henderson synthesized also some *p*- and *m*-menthadienes (with Sutherland, 1910; with Boyd, 1911; with Schotz, 1912; with Smeaton, 1920). Since the structures of these hydrocarbons were not determined it will suffice to illustrate this aspect of Henderson's work by one example. Thymol was catalytically hydrogenated by the Sabatier-Senderens process to menthol from which by dehydrogenation  $\Delta^3$ -menthene was prepared. This on treatment with bromine gave a dibromide from which by the action of alkali  $\Delta^{2:4}$ -*p*-menthadiene was obtained.

About 1924, Henderson entered the field of sesquiterpene chemistry. Here his attention was directed mainly to the hydrocarbon, cadinene and the caryophyllenes. He found with A. Robertson (1924) and with J. M. Robertson (1926), that cadinene could be isomerized readily to *isocadinene* for which on the basis of the then accepted *α*-cadinene formula (VII) the structural formula (VIII) was suggested.



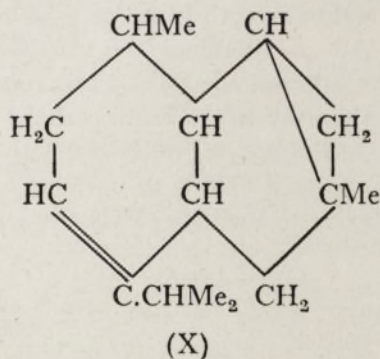
The formula for cadinene (IX) now advanced (Campbell and Soffer, *J. Amer. Chem. Soc.* **64**, 417 (1942)) makes this isomerization equally readily explicable.



As Henderson and Robertson point out *isocadinene* is identical probably with a hydrocarbon isolated by Troger and Feldmann (*Arch. Pharm.* **236**, 692 (1898)) and by Lepeschkin (*J. Russ. Phys. Chem. Soc.* **40**, 26 (1908)) from



oil of cade. Incidental to this investigation was the separation from the supra-oil (from *Sundora Wallichii*) of the hydrocarbon copaene (with McNab and Robertson, 1926). Since copaene is stated to give cadinene dihydrochloride on treatment with hydrogen chloride it can probably no longer be represented by (X) and this new source of the hydrocarbon may render possible a reinvestigation of its structure.



Henderson's final publications (with Robertson and Kerr, 1926; with McCrone and Robertson, 1929; with Bell, 1930) were concerned with the chemistry of the caryophyllenes. Perhaps the most important contributions which he made were the observations that whereas  $\alpha$ -caryophyllenic alcohol on dehydration gave solely clovene and on oxidation the crystalline acid, clovenic acid, the  $\beta$ -alcohol gave a mixture of clovene and isoclovene on dehydration and a liquid acid on oxidation.

J. L. SIMONSEN.

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