only to show how closely that question is connected with the points we have been discussing. I have here a gas flame to which I feed air until its yellow luminosity has disappeared. If I add to the air supply the fine spray of a dissolved copper salt, the flame assumes a green tint characteristic of the metal. This green tint seems to belong to the whole flame, but if we dissect it by the apparatus already so often used, we find that the green tint is developed only in the outer cone. It is due, in fact, to oxide of copper, which can only exist on the outside of the flame. Similar peculiarities are noticed with some other coloured flames, and it is hoped that their study, which leads us into the domain of spectrum analysis, will yield some interesting information on points which are at present very obscure.

I have directed your attention this evening to terrestrial flames of small dimensions, but in conclusion I should like to remind you that at one time there were probably quite other flames upon this earth. The globe we inhabit is in the process of cooling and of oxidation; at one time we believe, in fact we know, that it was incandescent. If we take a chemical retrospect and imagine as we recede in time our present cool earth becoming hotter, we may follow out some interesting changes. We should soon reach a temperature too high for the persistence of liquid water; our oceans would be evaporated and surround the globe as an envelope of steam. In remoter times and at higher temperatures this steam could not exist even as steam, but would be dissociated into hydrogen and oxygen. At that time, too, many of the elements now existing as oxides in the solid crust of the earth would be floating in a gaseous state in the vast atmosphere. Let us stop our retrospect at this point, and look towards the present with a cooling earth. At a certain point chemical combination must have begun in the fringe of the ancient atmosphere, and it must have been the scene of colossal chemical activities, the hydrogen and vaporous metals flashing into their oxides. On gravitating to hotter regions, these combinations may have been again undone, the elements sent again into circulation. How long such a period may have lasted we need scarcely stop to ask. If the retrospect is reasonable, it is enough. It is interesting to think how such an earth as we have pictured must have resembled the sun as we know it at the present day.

There was formerly a chemical theory of the sun, which ascribed both its heat and light to the act of chemical combination. That theory has long since been refuted and discarded, and with it ordinary laboratory chemistry banished from that luminary as altogether unsuited to its high temperature. There is cause, I think, to ask if this is quite warrantable. We know extremely little of chemistry at high temperatures, but if the sun could be shown to have its reasonable share of oxygen, we might well ask if its surface phenomena were not largely ascribable to ordinary chemical activities and of the nature of flames. It is certainly remarkable, when we consider the unity of plan in which heavenly bodies are seen more and more to move and have their being, that the sun should not exhibit the possession of its fair share of that element—oxygen—which has ruled the chemistry of the earth throughout all geological time and long precedent ages of its evolution. But this is ground which the terrestrial chemist must tread with care. He still has many unsolved problems lurking in the flame of a common candle, and flame, wherever we find it, is still a mystery.

"The power of *Fire* or *Flame*," says Carlyle, "which we designate by some trivial chemical name, thereby hiding from ourselves the essential character of wonder that dwells in it as in all things was with the old northmen Loke, a most swift subtle *Demon* of the brood of the Jötuns. The savages of the Landrones Islands too (say some Spanish voyagers) thought Fire, which they never had seen before, was a devil or god, that bit you sharply when you touched it, and that lived upon dry wood. From us, too," adds Carlyle, "no Chemistry, if it had not stupidity to help it, would hide that Flame is a wonder."

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—On Monday, the 20th inst., Prof. E. B. Poulton, the President of the Ashmolean Society, gave a *conversazione* in the University Museum, which was numerously attended by members of the city and University, who were specially invited to meet the Local Executive Committee of the British Association. The features of the entertainment were: an interesting lecture on features in the past history of science in Oxford, by Mr. Falconer Madan; physical experiments, by Prof. Clifton and Mr. J. Walker; exhibits of various entomological specimens from the Hope Collection; glass-blowing, by Herr Zitzmann; living animals and museum preparations, by Dr. Benham and Mr. Goodrich; physiological exhibits, by Messrs. Pembrey, Gordon, and Howard; and many other exhibitions which cannot be noticed for want of space.

The Junior Scientific Club, whose proceedings have been hitherto published in a somewhat haphazard manner, have decided to issue a series of fortnightly numbers, each of which contains an account of the papers read at the previous meeting. The first of these was published on the 17th inst., and is in all respects a credit to its editor. It contains, besides abstracts of papers read by Messrs. M. H. Gordon, S. A. Simon, and W. J. Waterhouse, a syllabus of all the papers read before the club during the past year, an obituary, and notes on the distinctions gained during the past year, by present and former members of the club.

At a meeting of Convocation held on Tuesday last, Dr. Arthur Thomson, University Reader in Human Anatomy, was appointed Professor of Human Anatomy.

CAMBRIDGE.—Mr. M. R. James, of King's College, has been appointed Director of the Fitzwilliam Museum in succession to Prof. Middleton.

An election to an Isaac Newton studentship in astronomy, astronomical physics, and physical optics, will be held in the Lent Term 1894. The candidates must be B.A.s and under the age of twenty-five. The studentship is worth £200 a year for three years. Applications to be sent to the Vice-Chancellor by January 26, 1894.

A syndicate has been appointed for the purpose of obtaining specifications and tenders for the erection of the Sedgwick Memorial Museum of Geology, in accordance with the plan of Mr. T. G. Jackson.

An influential deputation waited upon the Chancellor of the Exchequer on Tuesday in order to place before him the necessity for continuing, and, if possible, increasing, the Parliamentary grant of £15,000, which was conceded to the University Colleges in 1889. Sir W. Harcourt said that though he was prepared to recommend the renewal of the grant, the present condition of public finances would not permit him to propose its increase.

SCIENTIFIC SERIALS.

American Journal of Science, November.—On New England and the Upper Mississippi basin in the glacial period, by James D. Dana. During the recent discussions concerning the unity or otherwise of the glacial epoch in North America, it has appeared that workers in the central and western portions have mostly advocated two glacial epochs, while New England geologists have been the chief advocates of unity. The author has not found any facts in New England geology that require for their explanation an appeal to two glacial epochs, but has found an explanation of the appearances which have led western geologists to that opinion. The cause of this sectional divergence is mainly meteorological. Even at the present time, the precipitation in the east is far above that of the west, and in the glacial epoch the difference must have been still greater, owing to the greater elevation of the east. The conditions of the ice-sheet in the interior being near the critical point, a small meteorological change, if long continued, might carry off the ice for scores or hundreds of miles from a southern limit, while the eastern border was all the time gaining in ice, or was making only a short retreat.—On the use of the name "Catskill," by John J. Stevenson. Mr. Darton's suggestion that the term Catskill should be applied to the whole of the Upper Devonian period is inappropriate, since Catskill has been shown to belong to an epoch only, whereas "Chemung" carries with it the conception of those physical and biological characteristics which mark the great closing period of the Devonian.—The finite elastic stress-strain function, by G. F. Becker. This is an investigation of finite stress and strain from a kinematical point of view, and of the function which satisfies the kinematical conditions consistent with the definition of an isotropic solid. The bearing of the theory upon finite sonorous vibrations is compared with the corresponding deductions from Hooke's incomplete law.—A larval form of Triarthrus, by C. E. Beecher. Since the discovery of antennæ and other appendages of this trilobite by Mr. W. D. Matthew, it has been possible, with the new material supplied to the Yale Museum, to trace its development back to the earlier stages. Larval specimens have been found in which the thorax is undeveloped and the cephalon predominates, while the other parts are not clearly differentiated. The larva is ovate in outline. The frontal margin is marked by a convex fold of the test. The axis is annulated. Near the lateral anterior margins are two slight elevations which may represent the palpebral lobes of the eyes.

American Journal of Mathematics, vol. xv. No. 4.—On toroidal functions, by A. B. Basset (pp. 287-302). The theory of these functions was first investigated by Prof. W. M. Hicks, in his discussion of the motion of circular vortex rings (*Phil. Trans.* 1881). The author considers that Prof. Hicks presented the subject in a somewhat complicated form, and the object of his own communication is to develop the subject, and to correct errors which he attributes to Prof. Hicks. The memoir appears to be on the lines of a communication Mr. Basset made to the London Mathematical Society (April 13, 1893).—Simple groups as far as order 660, by F. N. Cole (pp. 303-315). This is a continuation of a paper in vol. xiv., in which it was shown that the orders of simple groups between the limits 200 and 500 are restricted to two possibilities, 360 and 432. In the present memoir the order 432 is shown to be inadmissible, and the order 360 to furnish only one type of a simple group. Two other simple groups are shown to present themselves, of orders 504 and 660 respectively. The order 504 "seems hardly to have been recognised hitherto." It was a singular fact, pointed out at the November meeting of the London Mathematical Society, that this memoir anticipated some results in Prof. W. Burnside's notes on the theory of groups of finite order. The latter had evidently arrived at his result quite independently of Dr. Cole.—On the expansion of functions in infinite series, by W. H. Echols (pp. 316-320).—The elliptic inequalities in the lunar theory, by E. W. Brown (pp. 321-338). This is a resumption of the author's paper from p. 263.—On the multiplication of semi-convergent series, by F. Cajori (pp. 339-343). The writer's object is to extend results given by A. Voss, in the *Math. Ann.* (vol. xxiv. p. 44).—On certain ruled surfaces of the fourth order, by T. F. Holgate (pp. 344-386). An introductory section is historical, and refers to previous memoirs on the subject. The author considers those species of the surface of the fourth order which may be generated by two projective sheaves of planes of the second order. These admit of a trinodal quartic section, and are consequently of deficiency zero. The volume concludes with a note on the so-called quotient G/H in the theory of groups by Prof. Cayley, (pp. 387-8), and the index of contents.

SOCIETIES AND ACADEMIES.

LONDON.

Physical Society, November 10.—Prof. A. W. Rücker, F.R.S., President, in the chair.—A paper on the separation of three liquids by fractional distillation, by Prof. F. R. Barrell, G. L. Thomas, and Prof. Sydney Young, F.R.S., was read by Prof. Young. Accepting the results obtained by F. D. Brown in his experiments on the variation in the composition of the distillate from a mixture of two liquids, viz. that the relative quantities of the two substances in the vapour at any instant are proportional to the weights of the substances in the still, multiplied by the ratio of their vapour pressures, the authors write Brown's equation in the form $\frac{d\xi}{d\eta} = c\frac{\xi}{\eta}$, where ξ and η are the weights of the two liquids in the still, and c the ratio of their vapour pressures. Taking c as constant, the above equation is integrated, and from the resulting expressions curves are plotted showing the changes in composition that take place during the distillation. Assuming that a similar law holds for three liquids, A, B, and C, viz. $\frac{1}{a}\frac{d\xi}{\xi} = \frac{1}{b}\frac{d\eta}{\eta} = \frac{1}{c}\frac{d\zeta}{\zeta}$, the composition of the distillate at any instant is calculated. Taking $a = 4$, $b = 2$, and $c = 1$ (numbers nearly proportional to the vapour pressures of methyl, ethyl, and propyl acetates), numerous curves are plotted showing the progress of the separation at various stages of fractionation. These curves show distinctly that although fractions containing large proportions of the liquids A and C, of lowest and highest boiling points respectively, can be easily separated, the middle substance, B, is much more difficult to obtain in a state of purity. Consideration of these curves led the authors to see that by carrying out the fractionation in a particular way, it was possible to separate the mixture into two portions, one containing only A and B, and the other B and C. These mixtures of two liquids could then be fractionated in the usual manner. This process was carried out on a mixture of methyl, ethyl, and propyl acetates, the results of which are given in considerable detail in the paper. The remarkable agreement between the densities of the ethyl acetates obtained respectively from the mixtures A and B, and B and C, as well as the fact that the densities of the separated liquids were the same as before the mixing, show conclusively that the method employed was highly successful. Prof. Ramsay said the paper was a most valuable one, and would be a great aid to chemists. Distillations were usually carried out by mere "rule-of-thumb," with the result that absolutely pure liquids could rarely be obtained. The President inquired whether curves representing the progress of distillation could be constructed from the very complete experiments made, and so test the assumed law. Prof. Young thought this not possible from the numbers obtained. To test the law in this way would be very laborious.—A note on the generalisations of Van der Waals regarding "corresponding" temperatures, pressures, and volumes, was read by Prof. S. Young. In November 1891 the author read a paper on the same subject (*Phil. Mag.* February 1892), and gave the critical molecular volumes of some twelve substances as calculated by M. Mathias. Since then a few small errors have been found in the calculation, and the authors' corrected values are now given. The vapour pressures, molecular volumes and critical constants of ten esters (methyl formate, acetate, propionate, butyrate, and isobutyrate, ethyl formate, acetate and propionate, and propyle formate and acetate) have recently been determined (Trans. Chem. Soc. lxiii. p. 1191). In the present paper the absolute temperatures and volumes of the twelve substances are given in terms of their critical constants, and tables given showing, respectively, the ratios of boiling points (abs. temps.) at corresponding pressures, to absolute critical temperatures; the ratios of volumes of liquid at corresponding pressures to the critical volumes, and ratios of volumes of saturated vapours at corresponding pressures to critical volumes, for the halogen derivatives of benzene, carbon tetrachloride, stannic chloride, ether; methyl, ethyl, and propyl alcohols, and acetic acid; and the extreme values for the ten esters previously mentioned. Whilst showing fair agreement with each other, the differences between them exceed errors of experiment. The ratios also indicate that the substances can be arranged in four groups, thus tending to show that molecular weight and chemical constitution have some influence on the results. The differences found would probably result from the presence of complex molecules, such as are known to exist in acetic acid. If Van der Waals's generalisations were strictly true, the ratio $\frac{pv}{T}$ at the critical point should be constant for all substances, as also the ratio $\frac{D}{D'}$ of the actual to the theoretical density (for a perfect gas) at the critical point. On comparing these quantities only a rough approximation is found, but the grouping of the compounds is again well marked. Prof. Ramsay was not sure that the existence of complexes would alter the molecular volume in the liquid state, for liquids seem very compact. Experiments on the surface energy of liquids had proved that complex molecules do exist in the alcohols and acetic acid. Dr. Young's conclusions were therefore confirmed by experiments of an entirely different nature. Prof. Herschel was gratified to see Van der Waals's theory so well borne out in liquids, and hoped to see it extended to solids. The recent researches of Prof. Robert Austen on alloys seemed to point in this direction. Mr. Rogers said molecular complexes do exert an influence on the properties of substances, as had been shown by Prof. Thorpe's viscosity experiments. Van der Waals's generalisations should therefore be looked at from a chemical as well as a physical point of view. The President thought the number brought forward showed fair agreements, especially when it was remembered that Van der Waals took no account of complex molecules. Contrary to Prof. Ramsay, he would rather expect aggregation to affect the molecular volumes in the liquid state, for only about one-fifth the space was supposed to be occupied by matter. On the other hand, the relatively