by one-sixth, and Prof. Joly's conclusion is that in Caledonian times there existed a metope of the uranium which we now know, with possibly very different properties. If this is true, the uranium clock has not been keeping uniform time, and the true age of the earth cannot be found by presuming that it has done so.

Prof. Sollas proceeded to explain and criticise the arguments whereby geologists are seeking to modify estimates of age based upon sedimentation, sea salinity, and denudation, so as to bring them more in accordance with radio-active and other physical calculations. He evidently considered these modifications not only premature (for reasons given earlier), but to some extent unsound. Geologists, he said, are not an undivided family, and proceeded to dissent, in anticipation, from the views of Prof. J. W. Gregory, read afterwards in abstract, owing to his regrettable absence, by Prof. Jehu. The necessity for modification of the hundred million years or so, based on the original salinity argument, was stated by Prof. Gregory to be due to certain omissions and untenable assumptions. It was assumed that the sea was originally fresh, although the oldest fauna, the Cambrian, has marine characteristics, and no allowance was made for large supplies of sodium chloride raised by magmatic waters from beneath the earth's surface. Denudation also was supposed to be uniform, although it was very improbable that this had been the case. The earth is now under the influence of a time of quick movement, whereas formerly it had alternated between times of repose and activity, owing to deformations which it had undergone. (One cannot refrain from quoting Prof. Sollas's comment that "we must no longer picture a time when the earth was 'young and wantoned in her prime,' but must suppose that she has exchanged the passive indolence of youth for the fiery activity of old age.") Altogether Prof. Gregory considered that the best-known geological estimates might safely be multiplied ten- or twenty-fold, thus bringing them into line with the physical evidence.

Prof. Eddington brought forward interesting evidence based on astronomical observations. He described the observed behaviour of certain variable stars, of which δ Cephei is a typical example, in which there is strong reason for supposing that the fluctuations of intensity are due to some intrinsic property of the star, and not to external influence. The observed change of period (itself a few days) of δ Cephei has been proved by a long series of measurements to amount to 0·08 sec. per annum, or 1 per cent. in 58,000 years. If the periodicity is associated with "pulsation" of the star it will be related also to the density in such a manner that the density of the star is changing at the rate of 1 per cent. in 29,000 years. From considerations of the luminosity of the star—a red "giant"—it would require an increase of density at the rate of 1 per cent. in *forty years* to provide the necessary energy according to Lord Kelvin's gravitational contraction hypothesis. We may conclude (1) that the star certainly has sources of energy other than gravitation, and (2) that Lord Kelvin's time scale should be lengthened in the proportion 29,000 : 40, or about 700 : 1, at least during this stage of its evolution. A considerable factor of the same kind would be required for the sun also, even though its evolution has progressed much further, so that it is now a "dwarf" star.

Owing to lack of time it was not possible for Dr. H. Jeffreys to take a verbal part in the discussion, and his remarks were communicated afterwards. Dr. Jeffreys's calculations are based upon two distinct considerations: (1) the temperature distribution downwards in the earth's crust, taking into account the radio-active content; and (2) the tidal theory of the origin of the solar system. It is not possible to do them justice here, but we propose to publish them in a later issue. Both theories lead to the estimate of approximately 2×10^9 years since the solidification of the earth's crust, which is in remarkable agreement with the results of other physical methods.

Sir Oliver Lodge, in a few words at the end of the discussion, pleaded for justice to Kelvin, whose calculation specifically assumed that "no source of energy other than gravitation existed." But Dr. Dear, with a rare eloquence which delighted the audience, would not let the matter rest there, but asserted that Kelvin arrived at his twenty-million-year estimate by three distinct methods, and regarded it as unalterable.

In closing the discussion the president, Prof. O. W. Richardson, laid stress upon the necessity for further careful experiments for the final elucidation of the problem.

The Constitution of Molecules.

THE joint discussion on the "Constitution of Molecules" by Sections A and B of the British Association aroused great interest, and the audience, which filled the large meeting room to its utmost capacity, included many visitors from other sections. Dr. Irving Langmuir introduced the subject with a clear and attractive presentation of the theory which is associated with his name and with that of Prof. G. N. Lewis. As originally published, this theory depended on a rather large number of arbitrary assumptions, but it has since been greatly simplified, and now involves only the three postulates described in NATURE of September 15, p. 101. The first of these postulates, according to which the electrons arrange themselves in the atom in definite layers of 2, 8, 8, 18, 18 and 32, is sometimes in conflict with the third, which requires that the residual charge on each atom and group of atoms should tend to become a minimum, and by giving greater weight to

one or to the other it is possible to bring the majority of compounds within the scheme. This possibility, whilst making it easy to find an explanation for a variety of facts, is an obstacle to the establishment of the theory on a firm physical basis. However, Dr. Langmuir is engaged on the quantitative examination of the consequences of the suggested distribution of electrons, and the progress made since the original publication in 1919 is so great that a still closer approximation to chemical facts may be expected with some confidence. One theoretical prediction, that of the salt-like character of lithium hydride, was mentioned as having been confirmed by experiment, and this confirmation is of some importance.

Unlike the Bohr atom, which is based mainly on the physical study of radiation, the Langmuir atom finds its chief justification in its power of accounting for chemical facts, and its presentation is almost entirely non-mathematical, so that it should make a special appeal to chemists. However, the discussion which followed the opening address approached the subject mainly from the point of view of physics and electro-chemistry, few chemists having yet considered in detail the bearing of the theory on organic or structural chemistry. The awakening of a greater interest in the subject of valency among chemists is likely to be one of the most useful results of the discussion, since the unsatisfactory position of the existing theories is well known, especially in regard to inorganic compounds, and the difficulties have usually to be evaded rather than met in the presentation of the subject. On Dr. Langmuir's view, it is incorrect to write structural formulæ for inorganic compounds such as salts, acids, or silicates, by using the same system of bonds as for organic compounds, electro-valency, which is represented by an electron passing from the sheath of one atom to that of another, being essentially different from co-valency, represented by the sharing of a "duplet" of electrons by two atoms. This distinction is an important feature of the theory, and is very ingeniously applied in the explanation of the structure of molecules of diverse kinds.

Prof. Smithells, whose interest in the matter is that of a chemist, exhibited a series of models of atoms and molecules which went far to make the suggested arrangements of electrons clear to the audience, models or photographs of models being almost essential to an elementary explanation. Prof. W. L. Bragg showed how the X-ray analysis of crystal structure leads to the result that each atom may be regarded as occupying a sphere of measurable and constant radius, a conclusion which is entirely in harmony with the structure of the Langmuir atom. On the other hand, he mentioned new evidence of an important character, derived from the diffraction of homogeneous X-rays by atoms. As X-ray analysis may be used to determine the position of atoms in a space lattice, so a further refinement of the method leads to conclusions as to the arrangement of the electrons within the atom. The results appear to show that most of the electrons are clustered together in the inner portion of the sphere occupied by the atom, that is, close to the nucleus, whereas the Langmuir structure, as at present assumed, requires that the number of electrons should be greatest in the outer shells.

Another difficulty arises from the static character of the Langmuir atom. Prof. Partington brought forward evidence from the molecular heats, which may be derived theoretically from a dynamic atom of the Bohr type, but are inconsistent with the arrangement which has been adopted to account for chemical valency. Sir Oliver Lodge, however, welcomed the remark of Dr. Langmuir that a static arrangement was not a fundamental condition of the theory, and suggested that chemists and physicists would find a dynamic atom the most suitable for the explanation of both classes of phenomena. A way out of the difficulty was suggested by Dr. E. K. Rideal, his view being that the atoms might be regarded as static except during the actual emission or absorption of energy, oscillation of the electrons under those conditions being more probable than rotation. Members of an assemblage of apparently like molecules differ in reactivity, this difference being attributed to an alteration of the position of one of the valency electrons relatively to the nucleus. This view awaits experimental confirmation.

Direct evidence in favour of the theory was produced by Prof. Rankine from experiments on the viscosity of gases. These lead to values for the dimensions of the chlorine molecule, for instance, corresponding with two argon atoms with their outer electron shells contiguous, and to similar relations between bromine and krypton, and between iodine and xenon. Further, on the assumption of the Langmuir structures, methane bears to ammonium the same relation as krypton bears to rubidium. Rubidium and ammonium are known from crystallographic evidence to have nearly equal molecular volumes, and an atom of krypton should therefore have the same volume as a molecule of methane. Determinations of viscosity prove this to be the case. Dr. S. H. C. Briggs gave reasons for writing elements as compounds of a nucleus with electrons, and for applying the ordinary type of equation for dissociation and similar reactions to elements as well as to compounds.

In the informal discussions which took place among members of Section B after the meeting it was possible to learn something of the attitude of chemists towards the theory. The distinction between electro-valency and co-valency is valuable, and the harmony between the new conceptions of the grouping of atoms and that of the space lattice in crystals is very attractive. The least satisfactory aspect of the theory is seen in its application to carbon compounds. The tetrahedral arrangement of the carbon atoms, confirmed by the X-ray analysis of the diamond, has not only accounted with wonderful success for the known facts of organic chemistry, but also has

proved itself invaluable in predicting new facts, so that it has now established itself in an almost impregnable position. Dr. Langmuir's atom, although presenting a tetrahedral aspect, is less able to adapt itself to organic compounds. A single bond, in the ordinary notation, is represented by an edge common to two cubes, a double bond by a face in common, so that an entirely different structure has to be adopted for a triple linking, and acetylene becomes one of the puzzles of the theory. It was also remarked that the model of sodium carbonate was essentially similar to that proposed by Werner, suggesting that the co-ordination theory might be elaborated to explain many chemical facts in place of a new hypothesis. It is probable that the study of valency will receive much attention in the near future, and that chemists will test each hypothesis thoroughly in its application to structural chemistry, which rests on an enormous mass of definitely established facts, with which a theory must be able to deal. In the meantime, the scheme of Dr. Langmuir, so clearly presented on this occasion, forms an excellent basis for discussion, and the Edinburgh meeting has served a most useful purpose in focussing attention on the difficulties, as well as on the advantages, of the proposed solution of the problem.

The Study of Bird-migration by the Marking Method.

THOUGH many valuable contributions have been made in recent years to our knowledge of the various phenomena associated with bird-migration, yet much remains to be accomplished.

One of the most important desiderata is to obtain definite information of a detailed nature as to the provenance of the migrants which arrive in spring, let us say, in the British Isles, and are widely or more or less locally distributed during the summer, and equally, or more widely, dispersed in their winter retreats. The same remarks apply to the numerous winter visitors: In what particular areas have they passed the summer? Do, for instance, redwings from Iceland winter with us as well as redwings from their wide-ranging summer haunts in Europe? Whence come the hosts of birds-of-passage which traverse our isles in spring *en route* for summer haunts in more northern lands, and return in the autumn on their way to their accustomed winter quarters? Each species comprised in these three groups of migrants is in all likelihood widely dispersed at both seasons, but as yet our knowledge is infinitesimal as to where the summer visitors to our country pass the winter, or where our winter visitors pass the summer, and we know nothing regarding either the summer or the winter haunts of the passage migrants.

In addition, more definite information is desirable as to (1) the routes followed by birds to reach their seasonal haunts; (2) whether the young seek the same summer and winter quarters as their parents; and (3) the winter retreats of the migratory section of certain British birds—the so-called partial migrants.

The difficulty in solving these important problems may fairly be described as insurmountable *in the main*; but it has been proved feasible to obtain glimpses of enlightenment, and it is most desirable to add to these glimpses, which, when correlated, become important. This may be accomplished in detail by the process called "ringing," and in its broader aspects through a knowledge of the distribution of racial forms, *if* such forms are based on well-marked characters. The ringing method is, however, the more promising, since the data so obtained are of a definite nature; and all who have the opportunity should cordially co-operate in forwarding the researches on these lines which are now being carried out.

With this end in view the University of Aberdeen instituted, in 1910, an inquiry for "The Study of Bird-migration by the Marking Method." This work was carried on for several years as a piece of research under the general direction of Prof. J. Arthur Thomson, to whose son, Dr. Landsborough Thomson, on whom the carrying out of the investigation devolved, we are indebted for the "Results," which were recently published in *The Ibis*. The total number of species ringed was about 100, and the number of individual birds 27,802. The total number of "reappearance records" (recoveries) was 879, or 3·2 per cent. But, as in other inquiries of a similar nature, many of the recoveries, as was to be expected, were made in the vicinity of the scene of marking, and after an insignificant period of time. Information of an important nature was obtained, some of which forms a valuable contribution to our knowledge of the seasonal distribution abroad and at home of the following species—namely, the lapwing, woodcock, starling, song thrush, swallow, hedge-accentor, mallard, herring gull, and blackheaded gull. The data regarding these have been carefully analysed and studied in all their bearings, and the deductions derived therefrom are given in detail. Regarding the rest of the species discussed, thirty-five in number, the data are not considered sufficient for such elaborate treatment, and for these brief summaries are given which afford in some cases records of considerable interest. There are also useful sections in which are discussed the purposes of bird-marking, its history, the interpretation of results, conclusions regarding bird-migration, and the value of the method of ringing, all of which are well worthy of perusal.

The University of Aberdeen is to be congratulated on its enlightened action in fostering this special piece of research, which, thanks to the labours and skilful treatment of one of its *alumni*, backed by the assistance of a number of enthusiasts, also *alumni*, has, greatly to his credit, been brought to a successful issue. W. E. C.