states that the fragments of sandstone, shale, &c., that he has found enclosed in the blue ground are conspicuously unaltered.

Much of the recent controversy has centred round the relation of the kimberlite dykes to the pipes. The fact that material of practically identical character to the pipe rock, and similarly brecciated, occurs in the form of dykes has long been known; but the latter have hitherto attracted but little attention, owing to the fact that the dyke material either carries no diamonds or so few as to be unworkable at a profit.

There can be no doubt that the dykes are genetically connected with the pipes, but were they formed contemporaneously, or did the dykes precede the pipes or *vice versâ?* Dr. Voit states that the pipes are younger than the dykes, which in all cases terminate, according to him, at the pipe-walls. Besides, fragments of dyke rock occur in the pipes, but pipe rock is never found in the dykes. Although chemically identical magmas, there are slight mineralogical distinctions, due, probably, to the different rate of cooling, which enable the rocks to be easily identified. Du Toit advocates the contrary view, namely, that the pipes and fissures have been formed contemporaneously. Between the extremes of occurrence in pipes or dykes he traces every gradation, and mentions "fissure-swellings," which, though dyke-like, expand at one or more points. Almost every pipe will be found to have one or more dyke-like offshoots, if not at the surface, at some greater depth. In the Newlands group, the pipes are connected below ground by a narrow dyke of kimberlite; on Secretaris, west of Kimberley, there are fissures with one or more little swellings on them, and there are numerous dykes and veins varying in width from mere stringers to belts of many feet. The strike of the fissures corresponds in some instances to that of the enclosing rocks (Newlands, Smith, and Peiser mines), indicating that the intrusion followed planes of physical weakness.

Instances might be multiplied to show the differences of opinion that obtain among South African geologists with regard to these interesting occurrences. They only emphasise the difficulties of the problems awaiting solution.

One word as to the date of intrusion. The pipes and fissures are later than the Karroo dolerites, which, in their turn, cut the Stormberg lavas. They are therefore at least of post-Rhætic age. If the melilite-basalt pipes of Sutherland are connected in origin with an intrusion of melilite-basalt in the Uitenhage beds at Spiegel River (Heidelberg, Cape Colony), then the occurrences of kimberlite are of post-Neocomian age (*vide* Rogers and du Toit, *loc. cit.*).

F. H. HATCH.

THE INDUCTION OF ANÆSTHESIA BY CHLOROFORM.

THE inquiry which was initiated seven years ago by the Council of the British Medical Association into the many-sided problem of chloroform-anæsthesia has added greatly to our knowledge, and directed particular attention to the fact that the administration of an amount of chloroform vapour above 2 per cent. in the inspired air is fraught with danger to the patient. The scope of this inquiry has been further supplemented and extended by independent researches carried out in this country and in France.

The view has been held, and to some extent verified by experiments, that during the progress of anæsthesia the drug was absorbed by the corpuscles rather than by the plasma of blood. The experiments of Benjamin Moore and H. E. Roaf first definitely proved that *in vitro*, with an adequate concentration or solution tension of chloroform in the blood, easily dissociable compounds or aggregations were formed between the drug and the proteins, including hæmoglobin, of the blood. It was a natural inference from these experiments that the production of anæsthesia, either in isolated cells or in unicellular or multicellular organisms, was due to the formation of such compounds between cell-protoplasm and chloroform. With a very small constant quantity of chloroform, 1 per 100,000, in blood it has been found that the anæsthetic effect is in no sense a cumulative one; the degree to which a living tissue is affected depends entirely upon the concentration of the chloroform in the blood, and therefore in the living cell, for the degree of anæsthesia remains constant, and persists for only so long as a definite solution pressure is maintained. Any given grade of anæsthesia is therefore entirely independent of the total amount of chloroform which is supplied at an adequate concentration. In the induction of anæsthesia in man the various stages from slight to profound must therefore essentially depend upon the gradually rising pressure of chloroform in the blood. When the amount of chloroform in inspired air is very low, the induction of anæsthesia is impossible; while that too high a percentage is lethal, the unfortunate accidents which occur from time to time bear abundant witness.

The rate of absorption of chloroform during the induction of anæsthesia has been studied by many observers, most of whom have attempted a solution of this problem by ascertaining the degree to which the lungs are ventilated during narcosis, and the extent to which chloroform is apparently retained by the body. This is determined by estimating the difference between the chloroform-content of inspired and expired air. In the case of inspired air this can easily be done with accuracy, but, especially with a low percentage of chloroform, the corrections which are necessary for temperature, amount of carbon-dioxide and aqueous vapour are so great as to render an accurate determination of the amount of chloroform in expired air a matter of much difficulty.

The rate at which chloroform is taken up by the blood can, however, be directly measured. In three papers just published in the Proceedings of the Royal Society, Dr. G. A. Buckmaster and Mr. J. A. Gardner have described the exact procedure of their experiments, which were undertaken with the view of ascertaining the function of the red corpuscles in anæsthesia produced by chloroform. Two of the papers fully describe experimental studies on "The rate of the assumption of chloroform by the blood during anæsthesia," and "The rate of elimination of chloroform from the blood after anæsthesia."

Hitherto an exact determination of chloroform in blood has been found to be difficult. It is not possible to use Neumann's method for chlorides. French observers, Tissot, Mansion, and Nicloux, have employed a method which is based on Dumas's reaction, which, as carried out by Nicloux, is rapid, convenient, and capable of giving satisfactory results, though it does not possess such a high degree of precision as an exact chemical method as does the one which was introduced by Carius for the determination of chlorine in organic compounds. This method was first used by Buckmaster and Gardner in their experiments on the anæsthetic and lethal quantity of chloroform in blood. The maximum error of this method never exceeds five per cent., and is generally much less. The amount of chloroform in the blood at any stage of anæsthesia is calculated from the difference between the chlorine-content of the blood of each individual animal before and after the induction of anæsthesia.

Buckmaster and Gardner had shown that when a mixture of chloroform and air is inhaled, almost all the drug is held by the red corpuscles; in one case no less than 98·5 per cent. of the total chlorine in the blood was found associated with the red corpuscles after 2 per cent. of chloroform vapour had been inhaled for three-quarters of an hour. It would appear, therefore, highly probable that in chloroform narcosis the transport of chloroform from and to the lungs is a function of the red corpuscles, which are the chief vehicle for the drug. If this is the case, it is obvious that although the absolute quantity of chloroform in the blood of any individual would vary with the mass of blood, the percentage amount in a sample of blood would not vary, other conditions being constant, whether the total amount of blood in the body was augmented or diminished. A large number of experiments were therefore performed, in order to elucidate this point. The general aim of these was to vary the mass of blood either by bleeding or by introducing the greater part of the blood of one animal into another of the same species. The blood was directly transfused. In experiments where the asphyxial state was reached rapidly, the average percentage of chloroform in the blood was found to be practically identical before (0·043 gram) and after bleeding (0·045 gram). In cases where the asphyxial state occurred half an hour to an hour and a half after the commencement of chloroform-inhalation, the figures were 0·048 before and 0·051 after bleeding. The paper gives full details of fourteen experiments which have been made as to the percentage amounts of chloroform in blood before and after hæmorrhage, and these, together with other experiments in which comparisons were made with a normal, with an augmented, and with a diminished mass of blood in the same animal, show conclusively that the percentage of chloroform in the blood does not vary with differences in the mass of the circulating blood. The results of the experiments are therefore in complete accord with what would be the case if, as Buckmaster and Gardner suspected, the red corpuscles were the essential agents for the transport of chloroform.

The curves which illustrate the chloroform-content of the blood during the induction of anæsthesia with 2 per cent. or 3 per cent. of inhaled chloroform vapour are of much interest. At the present time these curves, constructed from data fully given in tabular form, possess great interest. Not only are they the only curves which exist that show clearly the rate at which the percentage of chloroform rises in the blood from the commencement of the administration of the anæsthetic, but the fact which is so well known, that deaths during anæsthesia not infrequently occur within two or three minutes after the patient commences to inhale, is easily understood, for the chloroform-content of the blood mounts up so rapidly at first as to constitute a veritable danger-point. The amount or tension of the drug in the blood rises in the initial stage of anæsthesia with great rapidity to a value which approaches a maximum. If the individual passes this stage naturally, then after a distinct fall in the chloroform-content of the blood, the amount of the drug quickly rises again towards a maximum value, and an equilibrium between the factors which determine the amount of chloroform in the blood is subsequently obtained, the processes of intake and output at the surface of the lung going on side by side. This period corresponds to the second stage of anæsthesia. It may last for one or more hours, and represents the state of surgical anæsthesia. But the condition of the individual is far from one of safety, for although this stage can be maintained with an amount of chloroform in the inspired air which could not have induced anæsthesia, throughout the whole of this time the difference between the amount of chloroform which is present in the blood and what is found at the lethal point is very minute. The authors have laid special stress on this point, and from a careful examination of their curves it would appear that their contention is a sound one.

In their third paper Buckmaster and Gardner have studied the rate of elimination of chloroform after anæsthesia. Five typical experiments, accompanied with full data and curves, are given. During recovery from chloroform small quantities of blood were in some cases taken at intervals from an artery; in other cases the blood was taken by a long canula from the venous system close to the right auricle of the heart, and one curve is constructed from data obtained by analysis of samples, taken simultaneously, of arterial and venous blood from the carotid artery and the neighbourhood of the right auricle. The authors find that the rate at which chloroform is eliminated at the surface of the lungs is at first comparatively rapid, though subsequently this becomes much slower. But the initial rates of elimination are much less rapid than the initial rates for absorption, and therefore, on the whole, elimination of the drug is a much slower process than the assumption. From Tissot's observations it would appear that during recovery from chloroform anæsthesia the amount of the drug in venous blood constantly exceeds the amount in arterial, and he suggests that a study of the chloroform-content of arterial blood should be made during the induction of anæsthesia, and of venous blood during the disappearance of this state. Buckmaster and Gardner do not confirm all the results obtained by Tissot, though they are in entire agreement with him on the important fact that at the moment when the inhalation of chloroform is stopped, arterial blood always contains an excess of the drug when compared with the amount in venous blood.

The salient points of these researches have now been indicated. The application of an exact method, and the performance of a large number of experiments which were carried out under precisely similar conditions in the physiological laboratory of the University of London, have enabled Dr. Buckmaster and Mr. J. A. Gardner to complete this portion of their work, and their results will probably afford a sure basis on which a full knowledge of the physiology of the anæsthetic process during the inhalation of chloroform may in the future be built up.

ARCHÆOLOGICAL REMAINS IN WALES AND THE MARCHES.

IN the sphere of archæology the University of Liverpool bids fair to surpass all other British homes of learning, ancient or modern. Backed by a number of wealthy citizens, more cultivated than the corresponding class in any other town of the Empire, it has lent generous aid to the excavator, and is able to boast, at the present time, of a vigorous archæological school directed by men whose names are pledges of efficiency in their several departments. So far, however, it has interested itself mainly in the elucidation of classical history, in the study of Greek art, and in exploration in Asia Minor and Egypt. Now for the first time its attention is being directed to regions nearer home; at the instance of many Celtic scholars, and numbers of influential Welshmen both in the city and the Principality, it is undertaking the supervision of no less a work than the survey and