potato and roots, leaves, &c.—to be eaten at ease in the seclusion of the animals' burrows, or to be stored up for use in the winter. The food is passed into the pouches by the fore-feet; and the animals empty their pockets by pressing the sides of the head with the fore-feet from behind forwards, so that the contents fall out in front of them. In disposition Gophers are very fierce; and on the rare occasions on which they wander from their holes, frequently attack passers-by without any provocation. They are not very prolific animals, as is commonly stated, for only one litter of two or three young is produced in a year; but, although their rate of increase is slow, their mode of life protects them from many enemies which attack squirrels, mice, and many other rodents. The Pocket Gophers of the United States belong to three genera, *Geomys*, *Cratogeomys*, and *Thomomys*; Mr. Bailey gives two charts illustrating the distribution of these different genera and their constituent species.

COLOUR PHOTOGRAPHY.

AN important paper on the theory of colour photography is contributed to No. 6 of *Wiedemann's Annalen*, by Herr Otto Wiener. The paper deals with the methods of attacking this problem which are based, not upon the photography of the different constituents of coloured light and their subsequent recognition—like Mr. Ives's heliochromy and similar processes —but upon the direct production of colour by the influence of light upon certain chemical substances. The most recent, and in a way the most successful of these methods is that due to Lippmann, and the question raised by Herr Wiener is whether the old processes invented by Becquerel, Seebeck, and Poitevin are based upon interference colours like Lippmann's, or upon "body colours," *i.e.* colours produced by partial absorption of the incident light. That Lippmann's colours are due to interference may be very simply proved by breathing upon a plate with a photograph of the spectrum, when the colours quickly wander towards the violet end, this result being due to an increase in the distance between the nodal layers. This experiment cannot be applied to a spectrum photographed by Becquerel's method. But Herr Wiener succeeded, by a simple and ingenious contrivance, altering the path of the rays through the coloured film by placing a rectangular prism on the plate, with its hypothenuse surface in contact with the spectrum. This experiment had the startling result that that part of the spectrum covered by the prism appeared strongly displaced towards the red. Hence Zenker's theory of Becquerel's process, enunciated in 1868, which ascribed the colours to interference, is substantiated. Instead of Becquerel's homogeneous sheet of silver chloride containing subchloride, Seebeck used the powder, and Poitevin mounted the salt on paper. In these two processes the effect described is not observed. Hence these colours are body colours in these two cases. The production of these body colours is a very mysterious process, but the author hopes that here will eventually be found a satisfactory solution of the problem. To account for the production of these colours he advances a remarkable theory which has a well-known analogy in comparative physiology. Given a collection of compounds of silver chloride and subchloride of indefinite proportions, such as those which Mr. Carey Lea calls by the collective name of "photochloride," we must suppose according to the modern kinetic theories that they are undergoing a rapid series of successive modifications. When the red combination happens to be exposed to red light, it reflects it without absorption, and will therefore no longer be affected or changed by it. Similarly for the other cases. This is another process of "adaptation." The author describes some experiments which prove that this is the true explanation, and points out the importance of this view, not only for colour photography, but for the production of colours in the animal world.

THE SLATE MINES OF MERIONETHSHIRE.[1]

AN official Blue Book drawn up by a Departmental Committee appointed by Mr. Asquith, and referring to the dangers of slate quarrying in Merionethshire, has recently appeared. After a brief account of the mode of occurrence, the method of getting the slate by true mining operations is described, and the principal causes of accidents are enumerated and explained. Judging by the statistics of the last nineteen years, the underground worker in Merionethshire is exposed to greater risks than the average collier; some 40 per cent. of the deaths are caused by falls of rock, a fact which causes no surprise when one considers the conditions under which the slate-getters carry on their daily work in huge chambers, the roofs and sides of which cannot be examined without rigging up lofty ladders.

An interesting table of death-rates shows that the Merionethshire slate quarrymen are better off as regards the safety of their occupation than many other classes of workmen, such as navvies, railway servants, and sailors.

The medical evidence, especially that of Dr. Richard Jones, is very complete, and we learn that some of the ills of the Merionethshire quarrymen are practically of their own making. Judging by the report and the evidence upon which it is based, the men are not cleanly in their ways, and if their sober habits lead them to ruin their digestions by stewed tea, it becomes a question whether their so-called, but incomplete, temperance is an unmixed benefit.

For preventing accidents, the Committee make several useful suggestions; one of the most important is their advocacy of "channelling machines" or "groove cutters," for assisting in getting the slate, instead of violently wrenching off the blocks by blasting.

The value of the report is enhanced by some useful appendices, a copious index of the evidence, and several woodcuts and plates. The plates are noteworthy as being the first instances of reproductions of photographs in a Blue Book by the half-tone process. Five of the eight photographs were taken underground by magnesium light; the two best, which represent ladders set up in underground chambers, are the work of Mr. Burrow, of Camborne, already well known by his successful pictures of Cornish mines.

The report is signed by Mr. Le Neve Foster, the Inspector of Mines of the district, Mr. J. E. Greaves, the owner of one of the largest slate mines, Mr. E. P. Jones and Mr. J. J. Evans, both quarry managers of wide experience, and Mr. J. Jenkins, President of the Quarrymen's Union. The opinions of a practical Committee of this kind are entitled to consideration, and it will be interesting to note how far their suggestions are carried out, and how far they attain their object, viz. the increased safety and general well-being of the Merionethshire quarrymen.

[1] Report of the Departmental Committee upon Merionethshire Slate Mines, with Appendices. Presented to both Houses of Parliament by command of Her Majesty, 1895.

THE RELATION OF BIOLOGY TO GEOLOGICAL INVESTIGATION.[1]

II.

THE RELATIVE CHRONOLOGICAL VALUE OF FOSSIL REMAINS.

REJECTING the idea of special endowment held by early geologists, we must consider the relative chronological value of fossil remains with reference to the natural laws which have produced their characteristics and governed the various conditions of their origin. Much may profitably be said concerning the comparative chronological value of the different genera, families, &c., belonging to one and the same class of any branch of either the animal or vegetable kingdom, or to different classes; but I propose to discuss only the broader relations to one another of the more general kinds of fossil remains. These discussions will relate to the time-range of each of those general kinds, the various conditions under which they have been preserved, the various conditions of habitat of the animals and plants which they represent, the relative rate of evolutional development of the different kinds and their differences of reciprocal relation to one another.

No fact in historical geology is more conspicuous than that of the great differences in time range of the various kinds of organic forms, some of them having ranged through the whole of the time represented by the geological scale, while others, and among them some of the biologically most important kinds, ranged through only a comparatively small part of it.

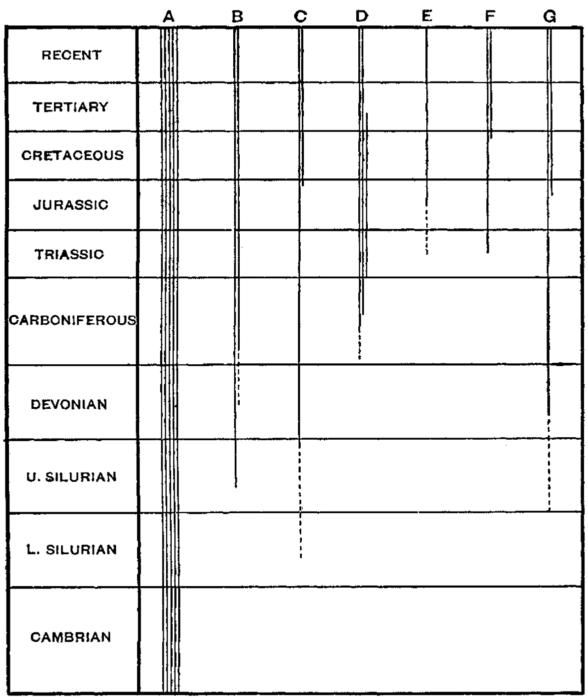
A special grouping of the different kinds of fossil remains is more appropriate for these discussions than is a strictly systematic one, and I have therefore adopted the following: (*a*) marine invertebrates, (*b*) non-marine and land invertebrates, (*c*) fishes, (*d*) batrachians and reptiles, (*e*) birds, (*f*) mammals, and

[1] By Charles A. White. Abstract of a series of eight essays published in the Report of the United States National Museum. (Continued from p. 261.)

(*g*) land plants. For convenience of reference, our present knowledge of the time-range of these kinds may be presented in tabular form. The accompanying illustration, representing the whole of geological time by its height, indicates in a general way by perpendicular lines the time-range of the kinds just mentioned, and remarks in following paragraphs further explain the known range of some of the subordinate, as well as that of the principal kinds.

The horizontal spaces of the table represent the systems or stages of the geological scale. The proportionate width of the spaces which contain the names of those systems or stages is not intended to indicate the actual ratio of geological time for each, but it may be stated as the general opinion of competent nvestigators that the portion of the scale from the Cambrian the Carboniferous inclusive represents a much greater length of time than does the portion from the Trias to the Tertiary inclusive. In other words, it is generally believed that the Palæozoic portion of the geological scale was of much longer duration than was that of the Mesozoic and Cenozoic portions together.

The perpendicular lines in the table, which are placed singly or in pairs or groups under letters of the alphabet from A to G



Time range of fossils.—(A) Marine invertebrates, (B) non-marine and land invertebrates, (C) fishes, (D) batrachians and reptiles, (E) birds, (F) mammals, and (G) land plants.

inclusive, represent the time-range of the kinds of animals and plants which have already been mentioned, and which for convenience of reference are again recorded with their corresponding letters at the foot of the table. This method of grouping the different kinds of animals and plants, as already intimated, is adopted only for present convenience in making comparisons of chronological values. All the principal kinds which are designated in the usual systematic classification are, however, included in these special groups, the few that are omitted being regarded as of little or no importance in this connection. The dotted portion of certain of the lines indicates uncertainty as to the real extent of the time-range which is shown by them, because of imperfect or doubtful representation of those kinds by discovered fossil remains.

Of all the animals which have existed upon the earth, and of which remains have been discovered, only those of marine invertebrates have been found to range through the whole geological scale. The time-range of these important portions of the animal kingdom is represented by the group of five perpendicular lines under the letter A. The marine invertebrate life thus represented includes the Protozoa, Cœlenterata, Annuloida, Annulosa, and Mollusca, the latter including the Molluscoida. That is, it includes five of the six sub-kingdoms or branches of the animal kingdom.

The non-marine and land invertebrates, the time-range of which is intended to be represented in the table by the two perpendicular lines under the letter B, are only insects and fresh-water, brackish-water, and land molluscs. The discovered fossil remains of all other non-marine and land invertebrates are regarded as either too rare or too unimportant to be profitably considered in the comparisons which are to follow. The longer of the two lines may be taken as representing the known time-range of insects, and the shorter that of land and non-marine mollusca.

The pair of perpendicular lines in the table under the letter C shows the approximate time-range of all the various kinds of animal remains which have been referred to the fishes. The shorter of the two lines indicates the known range of the teleostean fishes, and the longer that of the other kinds, the latter including certain forms that differ materially from any living fishes.

The time-range of batrachians and reptiles, so far as it is known, is shown by the three perpendicular lines in the table under the letter D, that of the dinosaurs alone being represented by the shortest line of the three.

The known time-range of birds is represented by the single line under the letter E. It is here assumed that most, if not all, the fossil tracks found in Triassic strata, and formerly referred to birds, are those of dinosaurs.

The two lines in the table under the letter F represent the known time-range of mammals, the longer line representing that of the non-placental, and the shorter that of the placental mammals.

The known time-range of land plants is represented by the two lines under the letter G. The shorter line represents the range of the dicotyledons and palms, and the longer one that of all other kinds. The algæ and diatoms are omitted from the table, as being of little or no importance in the comparisons and discussions which are to follow.

The earlier portion of the time-range for each of the kinds of animals and plants, as shown by the perpendicular lines in the table, is naturally more incompletely and indefinitely represented by fossil remains than is the later portion, because of the smaller variety and greater rarity of those earlier remains, and also in most cases because of the increasing difference in character from living forms which is observable from later to earlier formations. In some cases, however, the early portion of the time-range as it is now known begins so suddenly, and with forms of such high biological rank, as to make it evident that its real beginning was much earlier than it has yet been proved to be by actual discovery of fossil remains. The last-mentioned fact is of great importance in many respects, but it does not necessarily affect the question under consideration, because all estimates of the relative chronological value of fossil remains must be confined to the kinds already known, and the application of such estimates must refer only to those portions of the geological scale in the strata pertaining to which the remains are known to occur.

It has been shown that it is the general advancement in biological rank for all organic forms and for the whole of geological time that constitutes the ideal ultimate standard of measure for that time. It does not necessarily follow, however, that the geological scale is actually based upon the combined average rate of advancement of all those forms, because this is a factor which cannot be definitely ascertained. Still, in all cases it is necessary to apply that idea so far as is practicable.

In view of the facts recorded in the preceding paragraphs, the highest estimate of chronological value must necessarily be placed upon the fossil remains of those kinds which have existed under the most nearly uniform conditions through the whole of geological time, and which give evidence of the most nearly uniform advancement in biological rank. Accordingly, the remains of marine invertebrates possess legitimate claims to a higher estimate of chronological value than do those of any other kinds of animals or of plants.

It is true that the rate of development in biological rank of marine invertebrates does not embrace the entire advance for the whole animal kingdom, because it begins in the scale as it is now known with many highly organised forms, and ends without including the vertebrates; but this fact does not affect any of the necessary elements of their superior chronological value, which have just been mentioned. The following summary of facts relating to the marine invertebrates show their principal claims to the highest estimate of value in characterising the divisions of the geological scale, and in determining the geological age of the strata in which their remains are found.

The marine invertebrates embrace five of the six sub-kingdoms or branches of the animal kingdom.

They have coexisted in every stage of geological time, while the known time-range of other animals, as well as of land plants, has been very much less.

The preservation of their remains having been a natural consequence of the character of their habitat, they are faunally more complete than are those of any land animals, and for the same reason they are florally more complete than are remains of land plants.

They all lived under the same or closely similar conditions, and those conditions were more nearly uniform throughout all geological time than were those under which any other forms of life existed. Their remains have, therefore, produced a more nearly uniform chronological record.

Their relations to one another were wholly congruous, while the relations of all of them to all non-marine faunas and land floras was more or less incongruous, and in many cases extremely so.

The formations containing their remains are for the whole world and the whole of the geological scale far in excess of those which contain the remains of any other forms of life, especially the remains of land plants and land animals.

CORRELATIVE GEOLOGY AND ITS CRITERIA.

The term "correlative geology" is not in common use, but it is adopted as a present convenience in discussing the correlation of assemblages of strata as divisions or subdivisions of the geological scale as it is developed in separate regions, and the identification of formations within one and the same district or region. As here used, the term correlation refers to geological systems or other comprehensive series of stratified rocks which occur in different and more or less widely separated parts of the world, between which parts there is no physical continuity of strata, or none that it is possible to discover. Correlation applies to general geology, identification to local or regional investigations.

The latter may be discussed under two heads, direct and relative. Direct identification applies to formations the characteristics of which at one or more localities have been ascertained, and as these are naturally of limited geographical extent, the application is similarly restricted.

Although fossils in all cases constitute not only much the most, but usually the only, trustworthy criteria for such indentification of formations as is indispensable in the study of structural geology, the various kinds differ materially as to their relative value. This value, however, has no necessary relation to that which they may possess as indicators of geological time, or of the correlation of the strata containing them with those of other parts of the world. The two values are distinct, although one kind of fossil remains may often possess both.

While fossil remains unquestionably afford the most trustworthy and often the only means of either direct or indirect identification of formations, in the absence of these means the geologist often reaches conclusions in this respect by methods of reasoning that it would be difficult even for himself to formulate, and these conclusions are valuable in proportion to his acquirements and experience. Among these less clearly definable methods is that which takes cognisance of homogeny; that is, of a method in connection with which certain inherent lithological and stratigraphical characteristics, which are possessed by a formation or series of strata in one part of a given region under investigation, are accepted as evidence that it had a common origin with a formation or series presenting similar characteristics in another part of the same region. Such a conclusion necessarily implies that originally there was physical continuity of similar strata between such localities, and that it has either been destroyed or obscured.

This method of identifying formations is one of minor importance as compared with that which is based upon fossil remains, but unfortunately it has, especially within the last few years, been adopted by certain geologists in charge of important works, almost to the entire exclusion of palæontological considerations. Although it cannot be denied that in the hands of an experienced and broad-minded investigator this method of identifying formations is of great value, the fact remains that some of the most grievous mistakes that have ever thrown discredit upon geological investigation have occurred by its adoption to the exclusion of palæontological evidence.

It has been the custom of a large proportion of geologists to regard the geological scale as it has been established in Europe as the absolute standard for the whole earth. A necessary consequence of this view is their assumption that the systems which physically constitute that scale, and at least most of the divisions of those systems, may not only be recognised, but as clearly defined in all parts of the earth as they are in Europe, if in those parts contemporaneous deposits were made and still remain intact.

In view of known facts and principles, the idea held by the early geologists, as well as by some of those now living, that identity of fossil types proves synchronism or exact contemporaneity of origin of any two or more series of strata containing them, is quite untenable. The facts which have been presented also suggest that the term "homotaxy" must be used with some degree of latitude as to its application to the subdivisions of systems, because the order of sequence in the occurrence of the types which characterise them, respectively, in one part of the world is in another part sometimes partially reversed or partially interchanged. That is, the taxonomy of those divisions, as biologically indicated, is not the same for all parts of the world.

The presence in widely separated parts of the world of all the systems of the geological scale, as well as of some of their larger divisions, has been demonstrated by the labours of a multitude of geologists, so the fact of correlation is not called in question. The principal questions which are here raised concern the scope of correlation, or the limitation of the assemblages of strata, the relation of which to respective divisions of the scale is more or less obvious. These questions are of practical application in the study of the structural geology of any part of the world other than that in which the geological scale was established; but they are of such a character that they must be conventionally rather than arbitrarily determined.

For example, in discussing the questions which have arisen concerning the earlier and later limits of the systems of the geological scale in North America, the difference of opinion as to those limits have been wider and more various with regard to the later systems than to the earlier. This is because of the greater number and variety of the kinds of fossil remains to be considered in such discussions of the later systems. It is therefore evident that in reaching a conclusion as to the limitation of any of these systems, or of any of their subdivisions, it is necessary to take into consideration all available facts, physical as well as biological. It is equally evident that it is the duty of every American geologist to hold in abeyance any final decision as to the correlation of the groups of strata which he may study with the divisions of the European scale until all such facts have been duly and justly considered. In short, the idea of absoluteness in such cases is as much out of place as is the assertion or recognition of personal authority.

Although these remarks refer directly to North American geology and geologists, they are equally applicable to other parts of the world when reference is made to the scale as represented by the European rocks.

Notwithstanding the great excellence of the scale now in general use, and the fact that so little change has been made in it since it was first devised by the early geologists, the future progress of geological science will demand modifications the necessity for which will be especially urgent when the true character of correlation for all the principal parts of the earth has been ascertained. Hitherto correlation has been investigated with the single purpose of adjusting the series of formations which occur in each of the various parts of the world to the scale now in use; but although its general applicability to that purpose is not to be questioned, the ultimate result of the study of correlation will be to modify this scale and adjust it to the systematic geology of the whole earth. That is, the scheme of stratigraphic classification, which has been the main factor in adjusting the elements of systematic geology, must in turn be itself adjusted to the great system which it will have been the principal agent in producing.

CRITERIA OF PAST AQUEOUS CONDITIONS.

Among the more conspicuous facts in geology are some of those which relate to the manner of origin as well as to the original and present condition of the sedimentary formations. These subjects have already been discussed, and among those discussions are some references to the character of the water in which each formation was deposited. Studies of the sedimentary formations, especially those made from a biological standpoint, have demonstrated that the bodies of water in which they were deposited were of the various kinds that are now known; that is, some were marine, some fresh, and some brackish.

Upon physical evidence alone, it is not practicable to satisfactorily classify the sedimentary formations of the earth in such a manner as to serve the purpose of thorough geological investigation. Therefore such data are in this, as in most other cases, chiefly valuable as being accessory to the evidence afforded by biological data.

The biological criteria which are relied upon by geologists to distinguish from one another the sedimentary formations which have been produced in marine waters, or in those of inland seas, lakes, rivers, or estuaries, relate to the characteristics of faunas which now inhabit those waters respectively, and to the differences from one another of such faunas. That is, the conclusions which geologists reach concerning the questions just indicated are based upon now-existing physical conditions, upon the known character, structure, and habits of animals with relation to those conditions, and upon the assumption that in past geological epochs animals of a given character and structure had similar habits, and lived under conditions similar to those which are congenial to their living congeners.

The various bodies of water which existed during geological time, and which constituted the habitat of aquatic animals, were of the same kinds that now exist, namely, marine and fresh, together with those of the various intervening grades of saltness. Although it is probable that the marine waters of early geological time were not so salt as those of the present oceans, it is believed that this difference in saltness has not been so great as to make any appreciable difference as to legitimate conclusions of the kind that have been indicated. It seems to be especially evident that this difference has been thus inappreciable since the close of palæozoic time, since which time the greater part of the known unmistakably non-marine formations were deposited.

If all the known now living members of a given family are confined to marine, or to fresh waters, as the case may be, it is assumed that the habitat of the extinct members of such families were similarly restricted, and that the presence of fossil remains of such animals in a given formation, is, in the absence of conflicting facts, sufficient evidence of its marine origin on the one hand, or of its fresh-water origin on the other. Again, if a given family is known to have representatives now living in marine, brackish, and fresh waters, respectively, it is assumed that it had a similar range of habitat during past geological epochs. Therefore, the discovery in a given formation of fossil remains of a single representative of a family having such a varied range of habitat is not of itself sufficient to enable one to decide whether it was of marine, brackish, or fresh-water origin, and other evidence must be sought.

The criteria of past aqueous conditions here discussed are, of course, only such as may be derived from sedimentary formations and their contents. It cannot be said that there are any fully trustworthy physical criteria because a non-marine formation rarely presents any condition of stratification, or any lithological character, which is not observable in some marine formations. Still, there are many more or less valuable indications which may be observed and to some degree relied upon in the absence of fossil remains.

For example, although considerable accumulations of calcareous strata are sometimes found among the generally arenaceous strata of fresh-water formations, they have never been found to contain any important accumulations of regularly bedded limestones. Furthermore, estuarine deposits are often still more of a detrital character than are fresh-water formations, and also they more rarely contain calcareous layers. Therefore, if one should encounter a series of regularly bedded limestones, either magnesian or fully calcareous, he will rarely, if ever, be at fault in regarding them as of marine origin even without biological evidence.

In a large proportion of the non-marine formations, the stratification is less regular than is usually the case with marine formations. Still, this is by no means a certain criterion, and in some cases non-marine formations are found to rest so conformably upon the marine and to be so conformably overlain by them as to give little indication of the great difference in the condition of their origin.

These examples serve to show how indefinite is the character of physical evidence as to the past aqueous conditions under which the various sedimentary formations have been produced, but they serve to emphasise a statement of the fact that almost entire reliance must be placed upon the evidence furnished by fossil remains.

With reference to general indications of difference between marine and non-marine formations which are furnished by their fossil remains, we observe that a conspicuous difference lies in the comparative abundance and variety of forms of life which the fossil faunas of the formations respectively represent. Marine waters have always teemed with life in a wonderful variety of forms, and their fossil remains are proportionally abundant. The variety is less in brackish waters, and least of all in lacustrine waters. It is true that ichthyic life is abundant in some fresh waters, but never so generally abundant or so various as in marine waters. It is also true that molluscan life is often locally abundant in shallow fresh waters, but, as already several times mentioned, the variety is extremely meagre. All these peculiarities are distinctly observable among the fossil faunas of the non-marine formations.

Other general indications of difference between marine and non-marine formations are furnished by remains of land plants and animals. Open-sea formations are naturally free from any vegetable remains derived from the land, although coal and other materials of vegetal origin are not unfrequently found alternating with layers containing marine fossil remains. These, however, are regarded as cases of emergence of the bottom of shallow sea waters and the subsequent subsidence of the same as plant-laden marshy land. It is a matter of fact, the reason for which has been suggested in preceding sections, that plant remains of any kind, especially such as are in a classifiable condition, have so rarely been found associated with remains of denizens of marine waters, that the discovery of fossil plants in any formation is of itself presumptive evidence of its non-marine origin.

It has already been shown that the remains of land animals have so seldom reached marine waters, or, having reached them, they were probably so generally destroyed by the triturating action of coast waves, that the discovery of any of this kind of fossil remains in any formation may also be regarded as presumptive evidence of its non-marine origin.

The foregoing statements have been made with reference to indications which are either of a general character or without direct relation to the quality of the waters in which sedimentary formations have been deposited. All the direct evidence, as has been already fully stated, is derivable from the fossil remains of the denizens, especially the gill-bearing kinds, of the waters in which were deposited the formations under investigation.

Referring to the previous review of the animal kingdom, it will be seen that a large number of families of both fishes and invertebrates are confined to a marine habitat, and that every member of even some of the higher divisions is similarly restricted. For example, every known member of the classes Cephalopoda and Brachiopoda is confined to a marine habitat. It will also be seen that a certain small number of families, especially of the mollusca, are equally restricted to fresh waters. The significance of such cases as these has already been pointed out, but it is desirable to refer to them again.

Fossil remains representing any one of these kind of animals may be taken as positive evidence of the quality of the water in which the formation containing them was deposited, provided there shall be no room for reasonable doubt that the animals were really denizens of that water. That is, caution is necessary even in these more positive cases, especially when the amount of discovered fossil material is meagre.

Not only caution but the exercise of careful judgment is necessary in other cases. For example, it will also be seen by referring to the foregoing review that certain families, while most of its members are confined to one kind of water, may have one or more representatives in other kinds; and again, that certain families may have representatives in all the known kinds of habitable waters. In such cases as these it is plain that all evidence afforded by fossil remains, to be of any value, must be corroborated by other evidence.

Still, the cases are very few in which serious doubt need be entertained as to the true character of the water in which a given formation was deposited. This is especially true if the fossil remains are sufficient in quantity and perfection to approximately represent the whole fauna that lived in those waters. Indeed, if the facts which are recorded in this review are borne in mind, there need be no more doubt as to what was the quality of the water in which any given formation was deposited, than might arise concerning any other geological observation.

THE CLAIMS OF GEOLOGICAL SCIENCE UPON INVESTIGATORS, MUSEUMS, &C.

With reference to the ordinary pursuits of life it can hardly be said that, apart from a natural demand for respectable emulation, one's occupation has any claims upon him other than those which are either conventionally or legally imposed by society upon every one of its members. The geological investigator, however, is not only amenable to all such claims, but to others of a different nature which, although not enforceable by legal, and unfortunately not yet by conventional, penalties, are not less imperative in their character.

Much might be said in favour of the demands which may be made in the name of science upon the individual on the ground of justice and of moral and social ethics; but all considerations of this kind will be omitted, reference only being made to those claims which are supported by the urgent necessities of science itself. Claims of the kind referred to might be made in favour of all the various divisions of science; but on the present occasion the discussions will be confined to those which pertain to biological geology, including both its structural and systematic branches. With reference to the manner in which the subject is presented, it is proper to say that thehomiletic form has not been adopted merely from personal preference, but because it appears to be in the present case a proper and effective, if an indirect, method of calling attention to prevalent errors, and of suggesting necessary improvements in certain prevalent methods.

These claims of science will be considered not only with reference to the individual investigator, but to associations, museums, and geological organisations. Those which may be made upon the individual investigator relate to the manner of prosecuting his work and of publishing its results, and also to his final disposition of the evidence upon which his conclusions are based. Claims upon associations or societies relate to the character and methods of publication; those upon museums, to the conservation and installation of fossil remains, and of the records pertaining to them; and those upon organisations, to the preservation of the integrity of geological science.

In considering the claims of science upon the individual, it is desirable to make some reference to the amateur as well as to the special investigator. This recognition of non-professional work is desirable because the general subject of geology has acquired such a hold upon the popular mind, and the opportunities for making observations with relation to it are everywhere so common, that in every civilised country there is a multitude of persons who are in the habit of making more or less critical observations. Notwithstanding the usual limited and desultory character of such observations, they have often contributed materially to the general fund of geological knowledge, especially when accompanied by a faithful record and preservation of evidence. Indeed, some of the most valuable facts in geology have been brought out by amateur observers, who themselves were hardly conscious that they had made their way alone to the frontier of acquired knowledge; and from the ranks of such observers have arisen many of the leaders in geological investigation.

It has been shown that systematic geology could have no existence without the use of fossil remains, and also that without their use structural geology would be reduced to mere local and disconnected studies. It has also been shown that to arrive at a just estimate of the value of fossil remains in these branches of geology they must be thoroughly and systematically studied as representatives of faunas and floras, as well as tokens of the formations in which they are found. The proper collection and preservation of fossil remains is therefore a subject of the greatest importance. In view of these facts it is the plain duty of every geologist, upon beginning a piece of field-work in structural geology, to accompany every step of his examination of the strata by as full a collection as possible of the contained fossils, and to preserve them, together with notes recording the results of his observations and a statement of all the facts relevant thereto.

Fossils thus collected, and the facts concerning them recorded, become invested with a value which differs materially from that which is possessed by ordinary property, and the claims of science upon them and upon the investigator with relation to them at once begin. These claims, as just intimated, require that a careful descriptive record be made of the stratigraphical conditions under which the fossils are found, including a directive record of the locality and designation of the stratum from which they were obtained. They also require that these records should be inviolably preserved and made inseparable from every specimen by indices that shall be as intelligible to other investigators as to the original observer.

Apart from the claims of science such precaution is necessary, because reliance upon memory alone is always unsafe in the most favourable cases, and it can at best give rise only to such oral traditions as are out of place in scientific work. The immediate preparation of the records and indices just mentioned is also necessary, because, while every specimen is at all times competent to impart to an investigator all obtainable knowledge of its own character, it can of itself convey no information as to its original locality and stratigraphic position. With this information secured for a collection of fossils they may be made at all times available as aids to scientific research, not only by the collector, but by all other investigators.

The claims of science also require that immediately upon the completion of the original study of fossils thus collected and recorded, they shall be placed where they will be freely accessible to the scientific public, and that reference to their place of deposit shall be made in connection with their publication. It is needless to say that the only suitable places for such deposit are public museums. It is only when this indispensable evidence is thus made accessible that the public can exercise that arbitration over the accumulated results of the labours of investigators which has been shown to be imperative.

The preparation and publication of complete records concerning the locality and strata from which fossil remains are obtained are necessary even from a biological point of view alone, especially when those remains are studied with reference to the range of organic forms in time, and without such records fossil remains are comparatively worthless as aids in geological investigation. It is unfortunately true that a not unimportant proportion of the palæontological material contained in our best museums is without these essential records, and that many of the publications containing descriptions and illustrations of fossil remains give no satisfactory information as to the localities and strata from which they were obtained, or of the final disposition of the specimens. In such cases those authors and collectors have evidently assumed to decide for themselves and for science the exact taxonomic position in the geological scale of the strata from which their fossils came. In omitting such records as have been referred to, they seem to have considered any information unnecessary that would enable the scientific public to repeat their observations upon their specimens, or those which they may have made in the field, or to learn the biological characteristics of the formations from which their collections were obtained other than those which may be suggested by their own partial collections and their necessarily imperfect descriptions. It is doubtless true that such omissions have been largely due to an honest lack of appreciation on the part of authors and collectors of the importance of preserving such records, but it is to be feared that in some important cases the omissions or suppressions have been intentional. In the former class of cases the fact can only be deplored, but in the latter every geologist is justified in feeling that a crime has been committed against science.

The claims of geological science upon associations and societies are so generally and justly recognised, that only the one which relates to the manner of publishing the results of investigation need be referred to in this connection, and this reference will be confined to the necessity of enforcing the claims upon individual investigators which have already been discussed. This claim may be sufficiently indicated by reference to those last mentioned, and by the remark that if it is the duty of individuals to publish records of their observations in the manner that has been stated, it is plainly the duty of those persons who may be in charge of the means of publication to refuse to publish the writings of those authors who do not conform to that requirement.

The facts and principles which have been stated fully warrant the statements that individual authority can have no existence with relation to geological science, that the public must be the final arbiter of all questions concerning the value of proposed contributions to its advancement, and that a public exposition should be made of the evidence upon which any contribution to biological geology is based. In accordance with the last-named requirement it is necessary to consider the claims of this branch of science upon museums, the force of which is apparent when it is remembered that the material pertaining to it therein stored constitutes the vital evidence of the value of all contributions to its advancement, and that without such evidence this branch of science would be reduced to a mass of personal testimony.

In view of the great scientific value of fossil remains the following remarks are offered concerning the precautions which are necessary in their preservation. It is true that most, if not all, these precautions are observed in a large part of the principal scientific museums of the world, but it is also true that much remissness in this respect has occurred in others. Besides the propriety of referring to the latter fact, these remarks are necessary to complete my statement of the claims of science which constitute the subject of this essay.

Three general classes of specimens of fossil remains should be recognised in museum collections, namely, typical, authenticated, and unauthenticated. Under the head of typical or type specimens are included not only those which have been described and figured in any publication, whether original or otherwise, but those which have in any public manner been so used or referred to. While all such specimens as these should at all times be accessible to any competent investigator, the risk of loss or injury is so great that they should in no case be allowed to be taken from the museum building in which they are installed. Such specimens are in a peculiar sense unique, and there can be no substitution and no equivalent in value. Their loss greatly reduces the value of every publication any part of which is based upon them, and to that extent retards the advancement of science. It is not enough that other, and even better, specimens of presumably the same species may be discovered; the former constitute the original, the latter only suppositious evidence. Besides the risk of loss or injury to type specimens by removal from the place of their instalment, their absence is a disadvantage to science. That is, no one investigator should be allowed their use to the exclusion of any other.

The term "authenticated specimens" is here applied to such as have been studied and annotated by competent investigators and properly installed. Such material constitutes the bulk of every important museum collection, and next to the type specimens already mentioned, they are most valuable. Their increased value is due to the scientific labour that has been bestowed upon them, and it needs only the additional labour of publication to constitute them type specimens and to make them of like value. Authenticated specimens when installed are ready aids to all investigators of such value, that even the temporary removal of any of them from a public museum is, to say the least, of doubtful expediency.

Unauthenticated specimens are, of course, those which have not been studied and installed, and they constitute the great mass of material from which authenticated and type specimens are drawn. Among them are those which constitute the material evidence upon which original observations in biological geology are based. If these are accompanied by the records and descriptive notes which are essential to their value, they constitute proper material for acceptance by museum authorities; but if not, their instalment should be refused, whatever their character may be. That is, to apply a statement made in another connection, no specimen of fossil remains should be admitted to permanent installation in any public museum which is not accompanied by such a record of the locality and stratum from which it was obtained, as will enable any investigator to revisit the same. In every case of instalment such records should be so connected with every specimen as to be readily accessible, and so arranged that the danger of loss or disconnection shall be reduced to a minimum.

The foregoing discussion of the claims of science upon museums is intended to embrace reference only to those which are devoted to the preservation of material pertaining to biological geology, but they are of more or less general applicability. These partial claims alone demonstrate the important relation that museums hold to science and to civilisation as centres of learning and conservatories of the evidence concerning acquired knowledge. Museums should not only be made safe treasure-houses of science, but they should be what their name implies—temples of study—perpetually open to all investigators.

The claims of science upon geological organisations cannot be discussed at length here, but because the ratio of power for the advancement or retardation of science possessed by such organisations is so much greater than that of individuals working independently, it is desirable to make this brief reference to them. That power increases also with the ratio of the extent of the organisation, and it is largely centred in the director. His responsibility, especially if his organisation is a large one, is peculiar, and, to himself, of an unfortunate character. That is, while all, or nearly all, the advancement of science that may be accomplished by the organisation is the work of his subordinates, retardation, if it should occur, is mainly due to his failure to require that each branch of investigation should be prosecuted in accord with all others, and the case would be little less than disastrous should he himself favour *ex parte* methods, or fail to require a symmetrical development of the work in his charge. The claims of science upon geological organisations are therefore really claims upon their directors, and they are more responsible than any other class of persons for the preservation of the integrity of geological science.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

At a meeting of the Council of University College, Dundee, last week, it was announced that the trustees of the late Miss Margaret Harris had allocated a number of securities, valued at nearly £14,000, to establish a chair of Physics in the College, as recommended by the University Commissioners. The Council resolved to institute immediately a chair of Natural Philosophy; and an appointment will be made before the beginning of next session. Hitherto the classes of Mathematics and Physics have been combined. The salary will be £400 with share of the fees.

The invaluable *Record* of technical and secondary education continues, in the quarterly number just issued, the review of the work done by the Technical Education Committees of the English County Councils, commenced in the preceding issue. A summary is also given of the work of the Scotch County Councils, from which it appears that, out of a total of thirty-three County Councils, twenty-four are devoting the whole, and seven a part, of their grants to educational purposes, while two counties are applying the whole of the fund to the relief of the rates. Out of a total sum of £25,157 distributed among the County Councils of Scotland, £22,491 was devoted to education in the year 1893–94. Mr. P. J. Hartog contributes to the *Record* an illustrated description of the Owens College, Manchester.

The Town Trustees of Sheffield have (says the *Athenæum*) voted a sum of £10,000 towards the endowment of Firth College, with a view to enabling the authorities to affiliate it to Victoria University. The actual endowment of the College is £23,000, in addition to its income of £1200 from the State and £800 from the Corporation. It is understood that a total of £50,000 would be sufficient, but no more than sufficient, for the purpose of affiliation. A further sum of £5000 has been conditionally promised by Sir Henry Stephenson, and a public appeal is contemplated for the remaining £12,000.

SCIENTIFIC SERIALS.

The Quarterly Journal of Microscopical Science for March 1895 contains:—On the variation of the tentaculocysts of *Aurelia aurita*, by Edward T. Browne. (Plate 25.) Of 359 Ephyræ collected in 1893, 22·6 per cent. were abnormal in possessing more or less than eight tentaculocysts; and of 1156 collected in 1894, nearly the same percentage, 20·9 was obtained. Of 383 adult Aurelia collected in 1894, 22·8 per cent. were abnormal.—On the structure of *Vermiculus pilosus*, by E. S. Goodrich, gives a detailed account of this interesting Oligochæte, found near Weymouth in 1892. (Plates 26–28.)—On the mouth parts of the Cypris stage of Balanus, by Theo. T. Groom. (Plate 29.) "It may be regarded as tolerably certain that: (1) The antennæ of the Nauplius become definitely lost with the moult resulting in the production of the Cypris stage. (2) The biramous mandibles of the Nauplius become reduced at the same time to the small mandibles, the ramus being probably preserved in the form of the small palp. (3) The first pair of maxillæ arise behind the mandibles, and at a later date, as a small pair of foliaceous appendages. (4) The second pair of maxillæ arise still later, just in front of the first pair of thoracic legs (cirri)."—A study of Coccidia met with in mice. by J. Jackson Clarke. (Plate 30.)—Observations on various Sporozoa, by the same. (Plates 31–33.)—Revision of the genera and species of the