

with the massive and solid bones of the skeleton, and, especially, the enormous vertical extent of the compressed tail, indicate an aquatic life. This opinion was expressed by the writer in describing the first specimen found, and the discoveries since made have done much to confirm it. That these reptiles moved freely on land, also, is quite probable. Other genera of the group may have lived mainly upon the land.

The large number of specimens of the *Stegosauria* now known from the American Jurassic, and the fine preservation of some of the remains, enable us to form a more accurate estimate of the relations of the group to the other Dinosaurs, than has hitherto been possible. The presence of a predentary bone, and the well-developed post-pubis, are important characters that point to the *Ornithopoda* as near allies, with a common ancestry. These positive characters are supplemented by some points in the structure of the skull, and the form of the teeth.

There are, however, a large number of characters in which the *Stegosauria* differ from the *Ornithopoda*, and among these are the following:—

- (1) All the bones of the skeleton are solid.
- (2) The vertebræ are all biconcave.
- (3) All the known forms have a strong dermal armour.
- (4) The second row of carpals and tarsals are unossified.
- (5) The astragalus is coössified with the tibia.
- (6) The spinal cord was greatly enlarged in the sacral region.

The relations of these two groups to each other and to the rest of the known *Dinosauria* will be fully discussed by the writer in his monograph on the *Stegosauria*.

NEW HAVEN, CONN., October, 1887.

III.—ON CERTAIN ANOMALOUS ORGANISMS WHICH ARE CONCERNED IN THE FORMATION OF SOME OF THE PALÆOZOIC LIMESTONES.

By H. ALLEYNE NICHOLSON, M.D., D.Sc., F.G.S.,
Regius Professor of Natural History in the University of Aberdeen.

THAT many of the Palæozoic limestones are more or less extensively composed of the skeletons of various Invertebrate animals, sometimes in a perfect condition, sometimes more or less largely fragmentary, has long been known. In certain instances a microscopic investigation of these ancient calcareous sediments may fail to demonstrate the presence of organic remains, or may reveal but few of these. Thus there occur beds of lithographic limestone in the Palæozoic series which would seem to be simply of the nature of very finely levigated calcareous mud, the component grains of which were, however, doubtless derived, in the first instance, from the calcareous skeletons of animals. Again, it commonly happens, even in examples where the rock may to all appearance be little altered, that a limestone may be found on examination by means of thin sections to have undergone secondary crystallization, with the result of a more or less complete obliteration of the organic remains

of which it was originally made up. Such secondary crystallization is generally the result either of the application to the rock of pressure, or of dolomitisation. In the great majority of the ordinary Palæozoic limestones, it is, however, generally easy to show that the rock is essentially organic, in the sense that it is extensively or essentially composed of the calcareous skeletons of living beings. The organisms which are principally concerned in the formation of the Palæozoic limestones are, as is well known, the Crinoids, the Foraminifera, the Stromatoporoids, and the Corals. Less important, though nevertheless sometimes taking a conspicuous part in the composition of the older limestones, are the Brachiopods, the *Polyzoa*, various groups of Molluscs, and the Ostracodous Crustaceans.

In the present communication I wish to direct attention more particularly to some organisms which are largely concerned in building up certain of the Palæozoic limestones, but which cannot at present be definitely referred to a place in any of the groups of animals above mentioned. The organisms in question are curiously like one another in general form and mode of occurrence, at the same time that they differ entirely in their internal structure; and they have been referred to the anomalous genera *Mitcheldeania*, Wethered, *Solenopora*, Dyb., and *Girvanella*, Nich. and Eth., jun.

Genus MITCHELDEANIA, Wethered, 1886.

The organisms which compose the genus *Mitcheldeania* have the form of small rounded or oval calcareous masses, made up of capillary tubes, of an oval or circular shape, which radiate from a central point or points, and are intermixed with an interstitial tissue of very much more minute branching tubuli (Fig. 1). The larger tubes may be considered as zoöidal tubes, and the proportion which they bear to the interstitial tubuli varies in different specimens, and in different parts of the same specimen. Usually, the zoöidal tubes occupy comparatively extensive regions of the skeleton, being separated from one another by a limited number of the minute tubuli; the latter also occupying irregular tracts to the exclusion of the large tubes (Fig. 1, A and C). The zoöidal tubes further communicate with one another by means of large irregularly-placed foramina, resembling the "mural pores" of the *Favositidae* (Fig. 1, G); and they occasionally exhibit a few irregular transverse partitions or "tabulæ." Increase appears to be by fission. The interstitial tubuli communicate with one another by irregular pores in their walls, or by branching, and they constitute a sort of "cœnenchyma," in many respects resembling the cœnosarcial tissue of *Allopora* (see Fig. 1, C).

The genus *Mitcheldeania* was founded by Mr. Wethered (GEOL. MAG. 1886, Dec. III. Vol. III. p. 535) for the reception of certain singular little bodies which occur abundantly in parts of the Carboniferous Limestone of the Forest of Dean. The single species recognized was described by Mr. Wethered under the name of *M. Nicholsoni*,¹ and the author was good enough to submit some of his

¹ Mr. Wethered re-described and re-figured the species in the 'Proceedings of the Cotteswold Club,' 1887.

material to me for examination, thus enabling me to prepare for myself a series of thin sections. Owing, however, to its small size and to the minuteness of its component tissues, the investigation of *M. Nicholsoni* is attended with great difficulties; and I have been able recently to make a much more satisfactory study of the characters of the genus from a much larger species, which occurs abundantly in parts of the Carboniferous series of the South of Scotland, and which I shall describe under the name of *M. gregaria*.

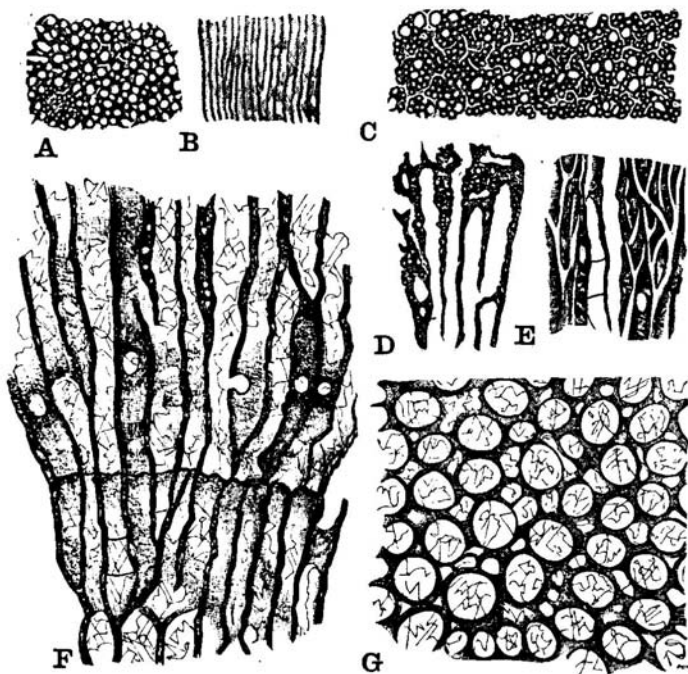


FIG. 1.—Minute structure of the skeleton of *Mitcheldeania gregaria*, Nich. A. Tangential section of part of the skeleton where the interstitial tubuli are comparatively few in number, enlarged 20 times. B. Vertical section of the same, similarly enlarged. C. Tangential section of part of the organism where the interstitial tubules are greatly developed, enlarged 20 times. D. Vertical section of a few tubes, enlarged 40 times. E. Vertical section of zooidal tubes, with interstitial branching tubuli, enlarged 40 times. F. Vertical section of a part with few interstitial tubes, enlarged 60 times, showing connecting pores and "tabule." G. Tangential section of a similar part, enlarged 80 times.

MITCHELDEANIA GREGARIA, n. sp. Figs. 1 and 2.

The organism occurs in the form of small rounded masses, approximately spherical in shape, and averaging about 10 millimètres in diameter, some examples exceeding this, while others do not reach this size. There are no traces of a peduncle of attachment, nor do sections exhibit any foreign body which might have served as a nucleus of growth. The surface may be smooth, but is

in general more or less lobulated, exhibiting under a lens, in well-preserved specimens, exceedingly minute pores. The skeleton is composed of radiating capillary tubes, disposed in concentric strata, and having a diameter of from $\frac{1}{12}$ to $\frac{1}{15}$ of a millimetre. In large portions of the skeleton these zoöidal tubes are placed near to one another, being separated only by a single row of smaller tubuli (Fig. 1, F and G), or being in direct contact. In other portions of the skeleton, the large tubes may be absent or may be scattered irregularly among very minute tubuli. These interstitial tubuli (Fig. 1, A and C) have a diameter of $\frac{1}{25}$ of a millimetre, or less, and usually occupy irregular patches of various sizes, between the groups of larger tubes. Vertical sections show that the large zoöidal tubes communicate with one another by oval or circular apertures, of comparatively large size, and uniserially disposed, the general aspect of these resembling that of the "mural pores" of the *Favositidæ* (Fig. 1, F). Very commonly, indeed usually, the zoöidal tubes appear to be free from internal partitions, but transverse plates, resembling "tabulæ," can sometimes be recognized here and there. No structures of the nature of radiating "septa" are present in the tubes. The interstitial tubuli appear to communicate with one another by minute pores; and vertical sections show that they commonly branch irregularly, and anastomose with one another (Fig. 1, E). Hence, in tangential sections of the areas occupied by the tubuli, there are generally seen minute branching canals interspersed among the cut ends of the tubuli, and resembling in aspect the cenosarcal canals of *Allopora* and *Millepora*, and of many Stromatoporoids (see Fig. 1, C).

This remarkable organism occurs in vast numbers in the Lower Carboniferous Series of parts of the South of Scotland and the North-west of Northumberland, and forms in places extensive beds of limestone. It was first brought under my notice by my friend Mr. Benjamin Peach, who informs me that it has a wide distribution; but the only locality in which I have personally collected it is

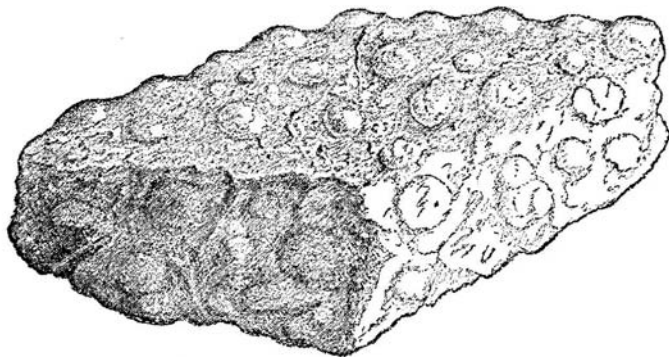


FIG. 2.—A fragment of limestone from the Lower Carboniferous Series of Kershope Foot, largely composed of *Mitcheleania gregaria*, of the natural size.

Kershope Foot, in Roxburghshire. Here beds of the limestone are more or less extensively composed of the bullet-shaped or grape-like skeletons of this singular fossil (Fig. 2).

There is no room to doubt that *M. gregaria* is congeneric with *M. Nicholsoni*, Wethered, from the Carboniferous Limestone of the Forest of Dean. It is, however, clearly a distinct species, not only being constantly of much larger size, but being also distinguished by marked structural peculiarities. Thus, *M. Nicholsoni* rarely exceeds four or five millimètres in length, and is very irregular in form, commonly enveloping other organisms, or forming crusts on foreign bodies. The zoöidal tubes in this species are also proportionately large in point of size, are few in number and irregular in distribution, and are separated by a great proportionate abundance of minute interstitial tubuli.

Thin sections of *Mitcheldeania gregaria* have a general resemblance to corresponding sections of certain Monticuliporoids, but none of the latter make any approach to the present form as regards the minuteness of the component tubes of the skeleton. The presence of connecting-pores between adjacent zoöidal tubes and of an interstitial canal-system would also separate *Mitcheldeania* structurally from the Monticuliporoids. In spite of the extreme minuteness of its tissues, the genus *Mitcheldeania* may, I think, be referred with tolerable certainty to the *Cœlenterata*. Admitting its Cœlenterate affinities, it would seem almost certain that the genus must be placed in the series of the *Hydrozoa*. There is, however, no known group of this class within which *Mitcheldeania* can be satisfactorily located. Its closest affinities seem to be with the *Hydrocorallines*, and in this connection I would particularly draw attention to the resemblance of the interstitial tissue of *Mitcheldeania* to the cœnenchymal tissue of certain species of *Allopora*. In one species of the latter genus which I have investigated the cœnenchymal tissue is not only very similar to that of *Mitcheldeania*, but is not so very much grosser in structure. On the other hand, all the known *Hydrocorallines* possess zoöidal tubes which are enormously larger than those of *Mitcheldeania*; and there are other morphological features in the latter genus which would preclude its being actually placed, with our present knowledge, in the group of the *Hydrocorallinæ*.

Genus SOLENOPORA, Dybowski, 1877.

This genus includes calcareous organisms, which present themselves in masses of varying form and irregular shape, and are composed wholly of radiating capillary tubes arranged in concentric strata. The tubes are in direct contact, and no "cœnenchyma," or interstitial tissue, is present. The tubes are thin-walled, irregular in form, often with undulated or wrinkled walls, without mural pores, and furnished with more or fewer transverse partitions or "tabulæ." No radiating "septa" are developed, but the type-species exhibits more or fewer inwardly directed septiform processes, which are the result of the rapid fission of the tubes (see Fig. 3, C).

The genus *Solenopora* was originally described by Dr. Dybowski (Chætetiden der Ost-Baltischen Silur-Formation, p. 124, 1877) for the reception of a singular fossil which is of common occurrence in the Ordovician limestones of certain localities in Esthonia. The structure of this organism has been fully dealt with by Mr. R. Etheridge, jun., and myself (GEOL. MAG. Dec. III. Vol. II. p. 529, Pl. XIII.), and we have shown its identity with the forms previously described by Mr. Billings as *Stromatopora compacta*, and by ourselves as *Tetradium Peachii*. The species stands, therefore, now as *Solenopora compacta*, Billings, the Scotch examples remaining as a variety, for which the name *Peachii* may be employed.

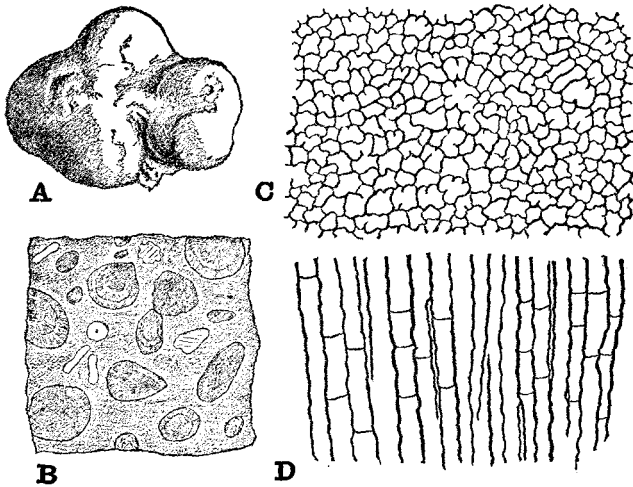


FIG. 3.—A, A small specimen of *Solenopora compacta*, Billings, from Saak, Esthonia, of the natural size. B, Surface of a piece of limestone largely made up of small specimens of the same, from the same locality, of the natural size. C, Tangential section of the same, enlarged about 35 times. D, Vertical section of the same, similarly enlarged.

SOLENOPORA COMPACTA, Billings, sp. Fig. 3.

This species has been so fully treated previously (*loc. cit. supra*), that it is unnecessary for me to enter here into any discussion of its characters. The accompanying illustration (Fig. 3) will sufficiently indicate its general form, mode of occurrence, and minute structure. As a species it is distinguished by the size of its component tubes (which vary in diameter from $\frac{1}{12}$ to $\frac{1}{20}$ of a millimètre), and by the facts that the tubes are irregular in shape, have undulated walls, and are furnished with more or less numerous septiform processes due to fission (Fig. 3, C and D).

It has been already shown by Mr. R. Etheridge, jun., and myself (*loc. cit.*), that *Solenopora compacta*, Billings, is very widely distributed in the Ordovician rocks, and that it played a very important part in the formation of certain of the limestones of this period.

We recognized its occurrence in the Trenton and Black River Limestones of North America, in limestones of corresponding age in Esthonia ("Jewesche Schichten"), and in the Ordovician limestone of Craighead, near Girvan, in Ayrshire. To the facts previously recorded with regard to the range of this remarkable fossil, I can now add some further information of interest. Thus my friend Prof. Lapworth has recently submitted to me a number of examples of this species, of unusually large size, which he has collected in the "Hoar-Edge Limestone" of Shropshire. This discovery has the effect of extending the known range of *Solenopora compacta* in Britain from the Ordovician area of Ayrshire to that of the classical district of the West of England. Again, I find that the fossils described by Mr. S. A. Miller, from the Cincinnati group of North America under the name of *Stromatocerium richmondense* (Journ. Cincinnati Soc. Nat. Hist. vol. v.) are in part referable to *Solenopora*, and are undistinguishable from *S. compacta*, Bill., sp. Mr. E. O. Ulrich has been kind enough to furnish me with a number of specimens from the Cincinnati group of Indiana, which he regards as referable to the so-called *Stromatocerium richmondense*. These specimens are in the form of small irregular calcareous masses, very closely resembling one another in general appearance, but differing so far that, when broken across, some show a conspicuous composition out of concentric layers, while others are more compact and uniform in texture. In point of fact, the specimens, in spite of their apparent similarity, are not all the same. Some of them are referable to *Solenopora compacta*, Bill.; others are referable to a species of *Girvanella* (= *Strephochetus*, H. M. Seeley); while others are composed of both these organisms growing in superimposed colonies.

SOLENOPORA? FILIFORMIS, n. sp. Fig. 4.

In the Ordovician limestone of Craighead, near Girvan, there occurs a fossil which I may provisionally describe under the above name, and which is associated with the preceding in the formation of the limestone. It is often present in great abundance in the limestone, but its internal structure is commonly much obscured, or even destroyed by crystallization. It presents itself sometimes in the form of small rounded or irregular nodules, or, at other times, as lobate or ramified masses of considerable dimensions. Viewed with a powerful magnifying glass it appears to be quite compact, or obscurely fibrous; but when examined microscopically, it is seen to be composed of exceedingly minute capillary radiating tubes disposed in concentric strata. The tubes are thin-walled, regularly prismatic in shape, without mural pores or radiating septa, but furnished with numerous transverse partitions or "tabulæ" (Fig. 4). The average diameter of the tubes is about $\frac{1}{24}$ of a millimetre. Increase of the tubes appears to take place by fission, but the tubes do not exhibit inward septiform processes, such as are so characteristic of the cross-sections of the tubes of *Solenopora compacta*.

I have some doubts about the reference of this fossil to the genus

Solenopora, as it differs from the type of the genus in important structural characters. This is more particularly seen in the regularly prismatic form of the component tubes of the skeleton, and in the total absence of the septa-like process produced in *Solenopora compacta* by the commencing fission of the tubes. At the same time, it agrees entirely with *S. compacta* in its general form and mode of occurrence, and especially in its being composed of imperforate, tabulate tubes of excessive minuteness. Upon the whole, therefore, it seems safest to place it temporarily in the genus *Solenopora*.

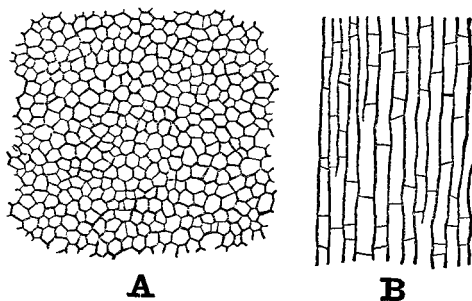


FIG. 4.—A, Tangential section of *Solenopora* ? *filiformis*, Nich., from the Ordovician limestone of Craighead, Girvan, enlarged about 60 times. B, Vertical section of the same, similarly enlarged.

It cannot be said that the present species throws much fresh light upon the systematic position of the genus *Solenopora*. If viewed without reference to the *size* of its tubes, it might quite well be regarded as a *Monticuliporoid*, and might be placed under the genus *Monotrypa*. The extraordinary minuteness of the tubes would seem, however, of itself, sufficient to preclude a reference of this fossil to the Monticuliporoids. If, however, we admit that the genus *Mitcheldeania* may be referred to the *Hydrozoa*, we can get over one of the principal difficulties attending the supposition that the genus *Solenopora* is referable to the same great class—the difficulty, namely, that no known Cœlenterate possesses a skeleton of such an excessively minute character. Upon the whole, therefore, I am inclined to think it may be tolerably safe to regard *Solenopora*, Dyb., as representing a peculiar extinct group of *Hydrozoa*, though I do not think that the evidence upon this point is in any way conclusive.

Genus GIRVANELLA, Nicholson and Etheridge, Jun., 1880. Fig 5.

Largely concerned in the formation of the Ordovician limestones of Ayrshire, and commonly associated with the preceding, is another remarkable organism which was described in 1880 by Mr. R. Etheridge, jun., and myself, under the new generic and specific name of *Girvanella problematica* (Mon. Sil. Foss. Girvan, p. 23, pl. ix. stone at Craighead, sometimes being the principal agent in the fig. 24). This curious fossil occurs in great numbers in the lime-formation of the rock, and presents itself in the form of small

rounded or irregular nodules, which vary in diameter from less than a millimetre to more than a centimetre. The larger examples (Fig. 5, A) show a distinctly concentric structure, visible even to the naked eye, but the most powerful lens fails to show any obvious internal structure in fractured or weathered surfaces. Examined microscopically by means of thin sections, the nodules of *Girvanella* are seen to consist of exceedingly minute circular tubes, endlessly contorted and bent, and twisted together in loosely reticulate or vermiculate aggregations (Fig 5, B). The tubes vary in their size from $\frac{1}{32}$ to $\frac{1}{16}$ of a millimetre in diameter. Most commonly they are about $\frac{1}{45}$ mill. in diameter. The walls of the tubes have a granular aspect, as if formed of exceedingly minute granules, but it is not possible to determine absolutely whether they are or are not truly calcareous in composition. No internal partitions are visible in the tubes, nor do they exhibit any perforations in their walls.

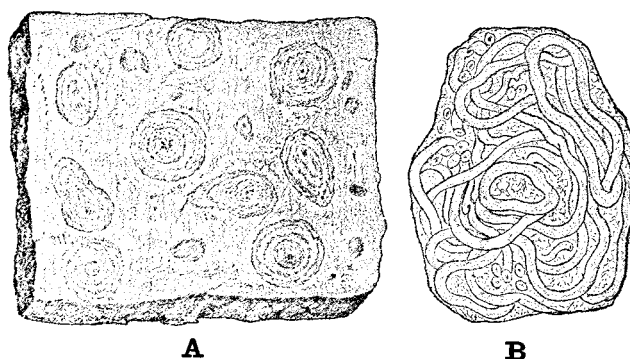


FIG. 5.—A, Fragment of limestone from the Ordovician rocks of Craighead, Girvan, of the natural size, showing numerous exceptionally large masses of *Girvanella problematica*, Nich. & Eth. jun. B, Section of a minute mass of *Girvanella*, enlarged about 60 times.

In the original description of *Girvanella problematica* by Mr. R. Etheridge, Jun., and myself (*loc. cit.*), the genus was provisionally referred to the *Rhizopoda*, and was regarded as related to the arenaceous *Foraminifera*. This view of the affinities of *Girvanella*, from which I see no reason to depart, was the one taken by Mr. H. B. Brady, to whom we had submitted our specimens; and this distinguished authority compared *Girvanella* with the recent *Hyperammina vagans*, figures and descriptions of which have now been published (see Chall. Reports, vol. ix. p. 260, pl. xxiv. figs. 1-9). The same author's great work on *Foraminifera* contains, however, another genus of arenaceous *Foraminifera* which admits, perhaps, of an even closer comparison with *Girvanella* than does the form above mentioned. I allude to the remarkable form described by Mr. Brady under the name of *Syringamina fragilissima* (Chall. Reports, vol. ix. p. 242, woodcut), in which the organism is free, and consists of a mass of minute arenaceous tubes disposed in concentric layers, and having a generally radiate arrangement.

In Britain, the genus *Girvanella* has, so far, only been recognized as occurring in the Ordovician limestones of Ayrshire. I have, however, found some of the Carboniferous limestones of the North of England to contain largely an ill-preserved organism which will, I think, prove to be referable to *Girvanella*. As previously pointed out, the genus occurs in the Ordovician rocks of North America. This is shown by the fact that certain of the specimens from the Cincinnati Group of Indiana sent to me by Mr. E. O. Ulrich as belonging to the *Stromatocerium richmondense* of Mr. S. A. Miller, prove on examination to belong to a species of *Girvanella*, specifically distinct, I think, from our British species, as shown by the greater minuteness of its tubes. I see, also, no reason to doubt that the fossils from the Chazy Limestone of North America, for which Prof. Henry M. Seeley has proposed (Amer. Journ. Sci. and Arts, 1885, vol. xxx. p. 355, 1885) the new generic name of *Strephochetus*, are in reality referable to the genus *Girvanella*. It is probable that the Chazy form (*Strephochetus ocellatus*, Seeley) is specifically distinct from *Girvanella problematica*, but its generic identity appears to be indubitable.¹ Prof. Seeley seems disposed to think that the curious fossil described by Prof. James Hall, from the Calceiferous Limestone, under the name of *Cryptozoön proliferum* (Thirty-sixth Ann. Rep. of the State Cabinet, pl. vi. 1884), may be related to *Girvanella*; but I cannot think that such a relationship—supposing it to exist—can be one of generic affinity. The fossil for which Prof. Hall has proposed this name is not only comparatively gigantic in point of size, but its internal structure, so far as may be judged from the incomplete provisional diagnosis given by its author, is altogether different, since it is stated to consist of branching and anastomosing canaliculi. Lastly, with regard to Prof. H. M. Seeley's reference of *Girvanella* (= *Strephochetus*) to the calcareous sponges, it need only be said that the structure of the genus, so far as recognized, shows nothing which would warrant such a reference, and that it would be essential to the establishment of this view, according to our modern lights, that the organism should be proved to possess definite spicules.

IV.—HERTFORDSHIRE SUBSIDENCES.

By A. C. G. CAMERON.

SUBSIDENCES are by no means unusual amongst the arable lands in the Chalk districts of this county. No one, who has travelled in these parts, can have failed to notice the numerous holes and dells dotted about the fields in all directions, many of which have fallen in, or will do so, in course of time. Nearly all of them mark spots where the Chalk has been dug up for chalking the land, which is then said to work better.²

On the crown of some hill or ridge, it is no uncommon sight to

¹ Dr. Hinde has already pointed out that *Strephochetus*, H. M. Seeley, is identical with the previously described *Girvanella*, and has further shown that the *Siphonema* of Dr. Bornemann, supposed by its describer to be a calcareous Alga, is likewise a synonym of *Girvanella* (GEOL. MAG. 1887, Dec. III. Vol. IV. p. 227).

² Gravel soils, such as fringe the modern alluvium of rivers and streams, are chalked as well as the stronger soils.