ing was devoted to the consideration of the best kinds of hammers, let the next produce some scheme for using them to some purpose. We wish the Society well, and it is therefore in true friendship we urge it to assume the proper dignity of labour for which it is so admirably suited.

ON THE DEVONIAN AGE OF THE WORLD.

BY W. PENGELLY, F.G.S.*

THE rocks composing the earth's crust contain a history and represent time—a history of changes numerous, varied, and important: changes in the distribution of land and water; in the thermal conditions of the world; and in the character of the organic tribes which have successively peopled it. The time required for these mutations must have been vast beyond human comprehension, requiring, for its expression, units of a higher order than years or centuries. In the existing state of our knowledge it is impossible to convert geological into astronomical time: it is at present, and perhaps always will be, beyond our power to determine how many rotations on its axis, or how many revolutions round the sun the earth made between any two recognised and well-marked events in its geological history. Nevertheless it is possible, and eminently convenient, to break up geological time into great periods: it must not be supposed, however, that such periods are necessarily equal in chronological, organic, or lithological value; or separated from one another by broadly marked lines of demarcation; or that either their commencements or terminations in different and widely separated districts were strictly synchronous.

One of the terms in the chronological series of the geologist is known as the Devonian, that which preceded it the Silurian, and the succeeding one the Carboniferous period; and these, with some others of less importance, belong to the Palæozoic or ancient-life epoch, or group of periods. The Devonian is, therefore, a chapter—it may be called the middle chapter—in the first volume of the organic history of the earth. It is this chapter, containing the history of the “Devonian Age of the World,” which is to furnish material for this article.

The period takes its name from the fact that it represents the era

* Being the substance of six lectures delivered at the Royal Institution from May to June, 1861.

during which the limestones, slates, and associated sandstones of North and South Devon were deposited. As nearly as can be determined, contemporary rocks occur in Cornwall, Herefordshire, Wales, Scotland, Ireland, France, Belgium, Germany, Russia, Turkey, Siberia, Tartary, China, Central and South Africa, Australia, Tasmania, Falkland Isles, Brazils, and various parts of North America.

The history of the period has been largely and ably illustrated by Hugh Miller, De la Beche, Lonsdale, Sedgwick, Murchison, Austen, Phillips, Rogers, Bigsby, and many others.

It appears to have been a period in which red deposits prevailed, the colour being due to the presence of the peroxide of iron. In this respect it is contrasted strongly with the Silurian beds below and the Carboniferous limestone above; the change, however, is in neither case uniformly sudden, so that by the test of colour alone it is not easy to draw a sharp line of separation between the Devonian and the more ancient or more modern system. The red colour is less prevalent in Devonshire,—this is especially the case in South Devon, where the deposits are chiefly clay-slates, and limestones, commonly grey or more or less blue. The characteristic red rocks are well developed in Herefordshire and many parts of Scotland, where they have been carefully studied under the name of "Old Red Sandstone," a term now generally regarded as a chronological synonyme for "Devonian."

Red colours, however, are by no means confined to the period now under notice; this, indeed, is implied by the epithet "Old Red," used for the purpose of distinguishing the deposits to which it is applied from others of the same colour above, and therefore more modern than, the Carboniferous formation; and which were formerly known, as they are still occasionally, as the *New Red Sandstone*. Here, again, it was necessary to speak of the *Upper* and *Lower New Red*, now the Triassic and Permian systems.

Nor are still more modern deposits destitute of this hue, as has been pointed out by Sir C. Lyell, when speaking of the Upper Eocene formation of Auvergne.*

The thickness of the Devonian rocks has been estimated at ten thousand feet in Herefordshire; at least twelve thousand feet in Ireland, and eleven thousand nine hundred and fifty feet in North America.

Considerable variety of opinion has prevailed respecting the age of the rocks of North and South Devon and Cornwall; nor is this surprising, since they are completely isolated, frequently display great metamorphism and mechanical violence, and have very few, if any, fossils in common with rocks, now known to be, of the same age elsewhere in the British Isles. Thanks, however, to the labours of Mr. Lonsdale, Professor Sedgwick, Sir R. I. Murchison, and others, they have been determined to be, as has been already stated,

* Manual, 5th Edition, page 109.

the chronological equivalents of the "Old Red" of Herefordshire and Scotland—much as they differ lithologically and palæontologically. Scotland does not yield the shells, corals and sponges so abundant in Devonshire; nor are the ichthyolites, with which the Scotch rocks teem, found in the latter district: this, however, has ceased to be a *chronological* difficulty, since the author of "Siluria" found the fossils characteristic of each of the areas lying together in the same Devonian beds in Russia.*

It is but right to add that many geologists well acquainted with the Devonshire rocks have accepted this chronological decision in a more or less modified form. Thus, the late Sir H. de la Beche regarded "The bulk of the Devonian and Cornish rocks as at least in part equivalent to the lower beds of the Carboniferous limestone, to the passage-beds between the Old Red Sandstone and Carboniferous limestone of Ireland, South Wales, &c., and also to some portion of the higher part of the Old Red Sandstones of Herefordshire and adjacent districts."† The late Rev. David Williams considered the Devonian system as occupying "an enormous interval between the Old Red Sandstone and the Mountain-limestone."‡

The late Mr. D. Sharpe, Professor Jukes, and Mr. Austen, have advocated the view that the rocks of Barnstaple in North Devon, and South Petherwin in Cornwall, belong to the Carboniferous system; whilst Mr. Salter would modify this, and class the upper portion of the Barnstaple group only as Carboniferous. The chronology of the Barnstaple and Petherwin beds will again come under notice, when discussing the distribution of the fossils of Devon and Cornwall.

That life existed on the earth during the era of the Devonian rocks is evidenced by the fossils they contain; unless, with the author of "Omphalos," we hold them to be *prochronic*. Indeed, the introduction of life dates very much earlier than this, since no fewer than very nearly one thousand species of organisms are recorded as having become extinct in Britain alone, in pre-Devonian times. The following table exhibits the amount and variety of life in the period under consideration, as compared with the fauna and flora now existing.

The figures in the 1st, 2nd, and 6th columns are copied from Bronn's "Index Palæontologicus," Quart. Journ., Geol. Soc., vol. i., page 44; and those in the 3rd, 4th, 7th, and 8th, are compiled from Professor Morris's Catalogue of British Fossils. It has been thought best to take no liberties with the originals, so that the authors alone are responsible for the correctness of the figures, which though possibly incorrect in a few cases, are on the whole the best that can be commanded.

* "Siluria," 3rd Edition, page 382.

† Mem. Geol. Survey, vol. i., p. 103.

‡ Report Royal Geol. Soc. of Cornwall (1843), p. 123.

		Species.				Genera.				
		Living.	Devonian.	Brit. Dev.	D. & C. Dev.	Dev. Spe.	Liv. Spe.	Devonian.	Brit. Dev.	D. & C. Dev.
Plantæ	Cellulares	9,100	6	1	...	7	2	1	...	...
	Monocotyledones	10,629	49	...	...	50	19	...	...	...
	Dicotyledones	49,674	...	...	...	...	...	...	...	...
Radiata.	Amorphozoa	300	11	9	9	33	6	4	4	...
	Infusoria	500	...	...	...	...	...	...	...	...
	Foraminifera	1,000	...	...	...	...	...	...	...	...
	Zoophyta	430	81	50	49	188	23	20	20	...
	Entozoa	1,500	...	...	...	...	...	...	...	...
	Acalepha	210	...	...	...	...	...	...	...	...
Articulata.	Echinodermata	498	82	15	15	165	18	6	6	...
	Annelida	770	8	...	...	10	4	...	...	...
	Cirripedia	107	1	...	...	9	1	...	...	...
	Crustacea	684	85	12	11	124	26	9	8	...
	Myriopoda	200	...	...	...	...	...	...	...	...
	Arachnida	600	...	...	...	...	...	...	...	...
Mollusca.	Insecta	65,000	...	...	...	...	...	...	...	...
	Bryozoa	380	53	11	11	147	22	7	7	...
	Tunicata	71	...	...	...	...	...	...	...	...
	Brachiopoda	48	131	109	108	2,729	16	17	16	...
	Lamellibranchiata	2,413	287	50	49	119	35	18	17	...
	Pteropoda	62	13	...	...	210	3	...	...	...
Vertebrata.	Gasteropoda	8,822	278	47	47	32	34	14	14	...
	Cephalopoda	128	270	48	48	2,109	9	5	5	...
	Pisces	8,000	110	91	...	14	47	34	...	...
	Reptilia	1,055	...	...	...	...	...	...	...	...
	Aves	7,000	...	...	...	...	...	...	...	...
	Mammalia	2,030	...	...	...	...	...	...	...	...
Totals		171,211	1,468	443	347	...	265	135	97	...

It appears, then, that all Devonian fossils are referrible to existing *classes*; hence the organisms which long since passed into extinction, and those which now exist, are parts of one whole; and, so far as these fossils testify, there are no extinct *classes*. Of the twenty-seven classes into which the present fauna and flora of the world are divided, fifteen are represented and twelve unrepresented by the Devonian series: * the latter are divisible into three groups, namely, Minute groups, as infusoria and foraminifera; Perishable, as entozoa, acalephæ, and others; and Complex, as reptilia, aves, and mammalia. It would be premature to assert that the first did not then exist. It is a question for the microscopist; and it may be doubted whether his attention has been so far given to it as to warrant any definitive opinion on it. Perishable forms can scarcely be hoped for in a fossil state, but it is not easy to dispose of the negative evidence respecting the Complex—the higher—organisms. True, that all the Devonian beds with which we can be said to be well acquainted are of marine

* Decotyledonous fossil plants have recently been found by Dr. Dawson in the Devonian rocks of Canada. See Quart. Journ. Geol. Soc., vol. xv., page 484.

origin; that they have not been thoroughly explored; and also that the occurrence of terrestrial organisms in marine-deposits must be the exception, and by no means the rule; still, it is not easy to explain away the facts that nothing analogous to the oceanic mammalia of the existing fauna, or the marine reptiles of the mesozoic epoch, occur in these old rocks; that even fish are not met with below the very uppermost beds of the Silurian system;—the “passage-beds” between it and the Devonian series—that below the middle Silurian rocks are poor in fossils, both specially and individually, in proportion as they are ancient;—fossil-poverty being in fact a function of antiquity—that the Longmynd rocks, in no respect ill-adapted for the preservation of organic remains, have, in all their vast thickness, yielded no more than some nine or ten species; that whilst the presence of phosphates may be fairly expected in strata in which organisms were once entombed, Professor Daubeny failed to detect the presence of any such salts in the Welsh slates; unless we suppose that the most ancient fossiliferous rocks with which we are acquainted were coeval in their origin with the earliest introduction of life on the globe; that life was at first, and for a very lengthened period, represented in the world by invertebrate animals and comparatively humble plants exclusively; and that there has been, on the whole, a “progression” from simple to complex forms as we pass from ancient towards modern times.

But even if we provisionally adopt this doctrine of organic progression, it must be with important limitations and qualifications. Admitting that the evidence at present before us is to the effect that the invertebrata appeared on the stage of life long before the vertebrata; and that, of the latter fish, were introduced earlier than reptiles, which in their turn held sway in the world for a considerable period antecedent to the advent of mammals: still the humblest representatives of each class were not always the first to appear, as, for example, in the class Pisces. Amongst the invertebrates, also, the lowly classes do not invariably appear earlier, or in greater specific or individual development than those of higher rank, as will hereafter be shown.

It must be remembered also that the argument for progression is entirely negative, and would be valueless in the presence of an opposing positive fact; so that, after all, perhaps the only safe verdict in the great case of Progression *versus* Uniformity, is “Non-proven.”

Of the classes represented in the Devonian series, *Amorphozoa*, *Annelida*, *Cirripedia*, and *Pteropoda*, seem to have been specifically unimportant, whilst the remainder were comparatively rich in species.* Equality in specific wealth in the various classes, however, by no means obtains now any more than in the earlier age under consideration.

In some cases it appears that classes poor then are still poor, as

* See Table 2nd column of figures.

Amorphozoa and others; others rich then are poor now, as Brachiopoda and Cephalopoda: whilst Gasteropoda, Lamellibranchiata, &c., abounding in species in existing seas, were formerly by no means thus characterized.* In order to show this numerical relation of the Devonian and existing species, the fifth column of figures, headed *Dev. Spe.*, *Liv. Spe.*, in the table, has been calculated thus:—the number of species in each class in the existing fauna, has, for the present purpose, been regarded as normal and put = 1,000, and the number in each of the Devonian classes equated to this; so that when compared with the specific development of the classes of the present day those of the Devonian age of the world stand, in ascending order, thus:—Cirripedia, Annelida, Pisces, Gasteropoda, Amorphozoa, Lamellibranchiata, Crustacea, Bryozoa, Echinodermata, Zoophyta, Pteropoda, Cephalopoda, and Brachiopoda. It will be seen also that the number of species in the two last exceeds, and in a high ratio, those of the same classes in existing seas; whilst those of Gasteropoda and Lamellibranchiata are more than correspondingly abnormally small. Here we have an example of a high class—Cephalopoda—preceding a lower one—Gasteropoda.

Though when the general fossil census was last taken, the Devonian rocks throughout the world yielded so many as one thousand four hundred and sixty-eight species;† yet if this number is considered in relation to the great thickness of the deposits of the period, the Devonian strata are poorer in species than either the Carboniferous or Upper and Middle Silurian; for example, for every one thousand feet in thickness the British Middle Silurian beds contain seventy-nine species; Upper Silurian ninety-six; Devonian forty-four; and Carboniferous one hundred and twenty. As a rule, deposits charged with peroxide of iron are poor in fossils; the red limestone of Petit Tor near Torquay, however, is an exception to this, as it is frequently crowded with *Orthoceratites* and other Cephalopods.

It is usual to divide the Devonian system into Lower, Middle, and Upper groups, and this triple division has been applied to Devon and Cornwall, especially by Professor Sedgwick, who recognizes the first, or lowest, in the slates and limestones extending from Plymouth to Torquay, in the limestones of Ilfracombe and Linton, the red sandstones of the north coast, and in the slates of Looe, Polperro, and Fowey, in Cornwall. This he designates the “Plymouth group.”

The middle division consists of the slates extending from Dartmouth to the metamorphic schists of the Start and Bolt and the slates and purple and greenish sand-rock, stretching in North Devon from Morte Bay, east and west across the country: this is termed the “Dartmouth group,” and is probably without fossils.

The upper includes the rocks ranging from Baggy point by Barnstaple, and the limestone beds and fossiliferous slates of South Petherwin in Cornwall: this is known as the “Barnstaple or

* *Ibid.*, 1st and 2nd column of figures.

† See “Total” Table 2nd column of figures.

Petherwin group," and is not supposed to have any equivalent in South Devon.* Accepting this chronology, at least for the present, there are, when considered geographically as well as chronologically, what may be termed five fossiliferous Devonian areas in the two counties, namely, one of the "Plymouth" age, in each of the districts, South Devon, North Devon, and Cornwall; and one of the "Barnstaple" age, in each of the two last; these, as a matter of convenience, may be termed Lower South Devon, Lower North Devon, Lower Cornwall, Upper North Devon, and Upper Cornwall.

Three hundred and forty-seven species of fossils, belonging to ninety-seven genera: forty-nine families and nine classes of animals, all invertebrate, are recorded as having been found in the five areas taken together. Of these, two hundred and ninety-six species are peculiar to one or other of the areas; and the remaining fifty-one common to two or more of them. Not a single species is common to all the areas; and only one, a coral, to four of them. The numbers found in each, local and peculiar, are as below:—

	L.S.D.	L.N.D.	L.C.	U.N.D.	U.C.
Peculiar	191	5	7	50	43
Total	226	15	15	78	73

No more than eight species have been found common to Lower South Devon and Lower Cornwall, closely connected as they are chronologically and geographically. This, however, can scarcely be considered remarkable, since the mineral characters of the deposits are very dissimilar; the Cornish beds are all but exclusively slates, whilst South Devon is rich in limestone. It is not easy to account for the fact that the two contemporary—scarcely-dissimilar, and not widely-separated—deposits of Lower South and North Devon have also no more than eight species in common; and that whilst as many as two hundred and twenty-six species are found in the former, no more than fifteen occur in the latter.

The organic connection between the upper beds of Devon and Cornwall is greater than in the case of any other pair of areas, and is what might have been looked for, from the facts that they are in *all* respects closely allied.

Sixty-seven of the Devon and Cornwall species are recorded as occurring in continental Europe, and seven in North America. Six of the seven are included in the European sixty-seven, and one of the six has been found also in Australia: hence the number common to Devon and Cornwall, taken as a whole, and districts beyond the British Isles, is greater than that common to the five areas of the two counties, in the ratio of sixty-eight to fifty-one,—that is of four to three.

Of the three hundred and forty-seven species, eight are Silurian forms and fifty-eight Carboniferous; none of the former number are included in the latter. The remainder, 281, are intermediate in character to those characteristic of the two periods just named, as

* Quart. Jour. Geol. Soc., vol. viii., p. 3.

was first announced by Mr. Lonsdale a quarter of a century ago. The evidence, therefore, of the fossils on the chronology of the rocks in which they were inhumed is, first, that they are of an age intermediate to the Silurian and Carboniferous,—that is, they are the equivalents of the Old Red Sandstone, second, that they are organically connected with both these periods; and third, that the connection is closer with the last than with the first. It seems probable, therefore, that whilst there is an ample development of Middle and Upper Devonian beds in the two counties, the lower group is less fully represented, and that the lowest beds of the district do not constitute the basement of the system.

Assuming that the South Devon beds are more ancient than those of Petherwin or Barnstaple—and probably no geologist entertains a doubt on this point—it follows that all the fossils common to the first, and either or both of the others, must be regarded as contributions from it to them: now this number is both absolutely and relatively greater in Petherwin than in Barnstaple. Again, of the two, the latter area has contributed the greatest number of species to the Carboniferous fauna. Hence, tried by either of the above as tests of relative age, Petherwin and Barnstaple are not strictly contemporary, but the former is more ancient than the latter; which is in unison with the opinion of Sir R. Murchison and Mr. Salter, based on other and, perhaps, more reliable data.* Indeed, Barnstaple has a smaller number of forms in common with South Devon than with the Carboniferous beds; hence it may be considered as rather belonging to the latter than to the Devonian series; or, possibly may have to be regarded as “Passage beds” between them.

The Devonian fossils of Devon and Cornwall belong to ninety-seven genera, as has been already stated. Of these, twenty-four are (in Britain) peculiar to the Devonian era; fourteen common to the Silurian and Devonian; forty-one to the Silurian, Devonian, and Carboniferous; and eighteen to the two last only. Hence thirty-eight genera die out, and forty-two commence existence in the Devonian age of the world. Several of the genera of the two last divisions pass upwards into Neozoic, and even recent times. Twenty-seven genera are recorded in British Silurian and Carboniferous lists which do not appear to have been represented in the Devonian fauna; an indication, perhaps, of the “imperfection of the geological record.” Few of the genera, not restricted to it, have their maximum specific development in the Devonian era, and the period is remarkable for the specific poverty of its genera; it falls below both the Silurian and Carboniferous period, and especially the latter, in both these respects. Generically, as well as specifically, the Devonian fossils of Devon and Cornwall have rather Carboniferous than Silurian affinities.

According to the catalogues Devon and Cornwall have yielded nine species of sponges, belonging to four genera; there is reason to

* Siluria, 3rd Edition, page 300.

believe that a greater number really exists. No fossils belonging to this class appear to have been found at Petherwin or Barnstaple; nor are any of the species known to belong to the Silurian or Carboniferous series. Polished sections frequently show these organisms surrounding foreign bodies, in most cases corals.

In 1843, Mr. Peach brought certain fossils, which Mr. Couch had then recently discovered in slate-rocks near Polperro in Cornwall, before the Geological section of the British Association, during its meeting at Cork. They were pronounced to be ichthyolites; and this, perhaps, the more readily from the fact that whilst the contemporary rocks of Scotland had yielded fossil-fish in great numbers. No more than, if so much as, the faintest trace of organisms of this class had been found in Devonshire and Cornwall; and this without the appearance of any reason for such absence.

Mr. Peach traced these fossils from near Fowey harbour to Talland sands, about two miles west of Looe. Subsequently they have been found, at by no means wide intervals, along the entire coast of Cornwall from Talland sands to Rame Head, near Plymouth sound. They have also been met with, but in small quantities, at Cliff on the left bank of the river Fowey, at Bedruthen on the north coast of Cornwall, and at Mudstone Bay, near Brixham, in South Devon.

Specimens were sent to the late Mr. Hugh Miller, who, at first inclined to confirm their ichthyic claims,—stating, indeed, of one specimen, that “If he had found it in the Lower Old Red Sandstone of Cromarty, he would have no hesitation in regarding it as a fragment of some dermal plate of *Asterolepis* ;” but on receiving a larger and more complete series, he prepared a paper on them, which was read before the Royal Physical Society of Edinburgh, in which he “doubted whether their true place in the scale of being had been determined,” and pronounced them “the most puzzling things he had ever seen; riddles on which to exercise the ingenuity of the palæontologist.” Soon afterwards Professor McCoy and Mr. Carter subjected them to a close microscopic scrutiny, which resulted in the fossils being pronounced to be sponges merely. A new genus, *Steganodictyum*, was established for their reception, of which they were found to constitute two species, *S. cornubicum* and *S. Carteri*. These fossils are found in slate-rocks only.

The remarkable fossil formerly known as *Sphæronites tessellatus*, has also experienced a variety of fortune among systematists. Rumour says it has been assigned to *Insecta*. In a note to Sir R. T. De la Beche’s paper on “The Geology of Tor and Babbacombe Bays,” the late Mr. Broderip says “It is not impossible that the fossil here referred to may have belonged to the *Tunicata*.*” Professor Phillips, after Mr. Austen, placed it, provisionally, amongst the *Sphæronites*, a genus of the family Cystideæ, belonging to the Cystoideæ, an extinct order of Echinodermata. Sir R. I. Murchison, more recently, says, “It is not, however, a Cystidean, that family

* Trans. Geol. Soc., 2nd series, vol. iii., part 1st, p. 164.

SPHEROSPONGIA TESSELATUS.

Showing internal structure. From the Limestone of Woolborough near Newton Abbot.

In the Collection of W. Penigelly, F.G.S.

Sketched in Stone from the Specimen by S. J. Mackie.

being confined to the Silurian rocks; but is, perhaps, a complex sponge.* The fossil is, accordingly, catalogued at present under the name of *Sphaerospongia tessellatus*. It occurs in the limestone beds at Lummaton, near Torquay, and at Woolborough Quarry, near Newton; one fine specimen recently found at the latter locality, shows that it is cup-shaped, the calyx, which unfortunately is somewhat broken, is elliptical,—having, at the top, its greatest diameter, about two and three-fourths inches, the least two inches, and narrowing almost to a point at the bottom. The depth of the cup is about one and a quarter inch. The walls are about one-twentieth of an inch thick; the inner surface is divided into a net-work of quadrilateral meshes, by the interlacing of, what may be termed, vertical and horizontal ribs. The former are, with slight variations, about three-twentieths of an inch apart, and are of two kinds,—primary, extending from the bottom to the top of the cup; and secondary, springing from various heights in the side or wall. The primary cycle consists of sixteen; the secondaries occur in pairs one on each side of a primary, of which they seem to be two branches issuing from the same node; these, in like manner, occasionally give off similar branches. The horizontal ribs are less prominent, somewhat thinner and closer than the verticals; they are about one-tenth of an inch asunder. Not unfrequently some irregularity is observable in their arrangement, being occasionally more or less out of horizontal, and not always at quite the same level on the opposite sides of the same vertical; so that as often as otherwise, they are not in one and the same straight line. In fact they sometimes remind one of the “bridging-pieces” which builders insert transversely between the flooring joists in houses for the purpose of securing stability. The surfaces of both sets of ribs, as well as the interstices, are covered with granules. Imagine the cup to be a gigantic calyx of some species of coral belonging to the sub-order *Zoantharia tabulata*, as, for example, *Heliolites porosa*; then do the vertical ribs represent the rudimentary septa, and the horizontal ones the tabulæ, which must be considered as rudimentary also.†

The beautiful specimen of this fossil figured in the Transactions of the Geol. Soc., vol. iii., part 1st, plate xx., fig. 1; and also in Professor Phillips' “Palæozoic Fossils,” plate lix., is lodged in the Jermyn Street Museum.

The genus *Stromatopora*, formerly regarded as belonging to the corals, but now removed to the sponges, contain five Devonian species, all of which appear to be confined to British localities, with the exception of *S. concentrica*, which occurs also in the Eifel. It is extremely abundant in the South Devon limestones, and not unfrequently attains a very great size.

* Palæozoic Fossils, p. 135.

† Siluria, 3rd Ed., p. 298.

‡ This is merely meant as illustrative, and not as a suggestion that the fossil is a coral.

In the Devonian deposits throughout the world about one hundred and fifty species of fossil corals have been found, forty-nine of which occur in Devon and Cornwall. Twenty-three of these are found in continental Europe, and six in America; five of the six are included in the European twenty-three, and one of the five has been met with in Australia. The British Devonian corals belong to twenty genera, six families, and the three sub-orders, *Zoantharia tabulata*, *Z. perforata*, and *Z. rugosa*.

The genus *Favosites*, belonging to *Z. tabulata*, contains five species, all of which have a wide geographical range. *F. Goldfussii* frequently attains a very large size; masses upwards of two feet in diameter are sometimes met with. It is also remarkable for its great distribution in space, occurring in Devonshire, at Nehou and Visé in France, at Millar in Spain, in the Oural, in the states of Ohio and Kentucky in America, and in New South Wales; yet it was confined to the Devonian era. It was formerly confounded with *F. Gothlandica*, a Silurian species. *F. cervicornis* is remarkable for its great abundance in certain localities: at East Oghwell, near Newton, a very considerable mass of limestone seems to be entirely composed of it, to the almost total exclusion of other fossils. *F. fibrosa* occurs also in Lower Silurian rocks in South Wales, and in Upper Silurian in Shropshire.

Pleurodictyum problematicum is the only species, not only of the genus, but also of the family (*Poritidæ*), and even the sub-order (*Zoantharia perforata*) which occurs in Palæozoic rocks, all its affinities are with organisms of much later times: it is a small islet of vitality, separated by a vast ocean of time from the organic continent to which it belongs. In Britain it occurs in the slate rocks at Meadfoot, near Torquay; at Oghwell, near Newton; and in great abundance, and of great size, at Looe in Cornwall; but has not been found anywhere in limestone.

The genus *Cyathophyllum*, belonging to the palæozoic sub-order *Z. rugosa*, contains fourteen species, that is, two-sevenths of the entire series. A small reed-like variety of *C. caespitosum* occurs in such numbers at one locality known as the Land's End, near Torquay, as to furnish a very faithful example of a coral-reef of the Devonian period. *C. Bucklandii* is the only British Devonian coral not found in South Devon.

Chonophyllum perfoliatum is recorded as occurring in Upper Silurian rocks as well as in Devonian; its great vertical range suggests the belief that it possessed a hardy plastic constitution, seeing it had lived through changes such as must have been introduced during lapses of time great as those represented by the terms "Silurian" and "Devonian;" and from such a constitution it might be supposed to have had a wide geographical distribution; nevertheless, it seems to have been particularly limited in this latter respect, thus contrasting strongly with *Favosites Goldfussii*, which, as has been stated, circumnavigated the globe during the Devonian age, to which it was confined; whilst *Chonophyllum perfoliatum*, which

Fig. 1.

TRIMEROCEPHALUS LÆVIS. (perfect.)
Volcanic Ash, Knowle, Newton Bushell, S. Devon.

Fig. 2.

TAIL & HEAD WITH EYES OF BRONTEUS FLABELLIFER.

*Limestone, Woolborough,
 Near Newton Abbot, S. Devon.*

Sketched from the Specimens.

On Stone by S. J. Mackie, F.G.S.

formed part of both the Silurian and Devonian faunas, was confined to a very limited district in each period.

Blastoidea and *Crinoidea* are the only orders of Echinodermata found in Devon and Cornwall; the first is represented by a single species, *Pentremites ovalis*, and this is only met with in the Barnstaple area; it occurs also in the Carboniferous period, as do all the other species of the genus.

Fourteen species of *Crinoidea* belonging to five genera and two families have been found in Devon and Cornwall; two of these occur also in continental Europe in rocks of the same age, and five in carboniferous beds; but not one seems to have been derived from the Silurian series. Parts of the stems are extremely numerous occasionally, both in the slates and limestones; bodies are very much less frequently found, and arms seldom if ever. Good examples of the body of *Hexacrinus interscapularis*, but without stem or arms, have been found in the Woolborough quarry near Newton.

Excepting *Cypridina serrato-striata*, found at South Petherwin, all the crustacea of the two counties are Trilobites. No traces of *Pterygotus*, *Eurypterus*, or *Estheria*—found in other British Devonian localities—have been met with. The trilobites belong to ten species, seven genera, and six families; hence the genera and families are very limited in specific development. With the single exception of *Phacops granulatus*, found at Petherwin, they all occur in South Devon, and are all confined to the Devonian era excepting *Phillipsia Brogniartii*, which is also met with in carboniferous beds in many and widely-separated European localities; this was eminently a carboniferous genus having no Silurian representative, but in all other cases the generic affinity was with the Silurian age. Indeed, the trilobitic form of life had passed its culminating point before the commencement of the Devonian age of the world—the evening of the group had already begun: no fewer than a hundred and seventeen species had previously become extinct in Britain alone; of these, ninety-eight belonged to twenty-one genera and seven families, which had also entirely disappeared from the earth.

Phacops latifrons occurs in the calcareous slates at Roseland Vale, near Liskeard, in Cornwall, where it seems to have attained considerable dimensions: in many cases the eyes, though somewhat flattened, are otherwise well preserved, not a facet being scratched. It has also been found at Croyde and Barnstaple in North Devon, and in clay-slate at Black Hall, near Totnes.

The tail of *Bronteus flabellifer* is by no means rare in the limestone of Woolborough, near Newton, and Lummaton, near Torquay; no part of the thorax seems to have been met with, but one example of a tolerably distinct head with eyes was found at the former locality.

Trimeroccephalus laevis, the only British species belonging to the genus, occurs under somewhat remarkable circumstances. So far as is at present known, it has been found only in one locality, namely, on the flanks of a hill called Knowles, near Newton, and no other fossil of any kind has been seen there. On this point our knowledge

is expressed by saying there is but one locality for the fossil, and but one fossil for the locality. Many hundreds of specimens have been found, and but two instances are known to have occurred in which the head was attached to the thorax. On splitting a stone, and thereby disclosing one of these trilobites, except in the two cases just named, the head is not visible; or what is much more frequently the case, one half the stone is found to contain the thorax and tail united, and the *impression* of the head, whilst in the other half are found the head and the *impression* of the body, and always in such a way as to show that the head had been severed from the body, removed a short distance from it, as if drawn or pushed forward, and inverted. In the cases where the head has not been visible, it has generally happened that it has been concealed by a mere film of the imbedding matrix, and can be found with a little care. When so found it tells the same story. There are never any indications of eyes; not unfrequently the tail appears somewhat truncated, as if its terminal margin were slightly folded or tucked under. It is clear that an inversion of the head might have been effected by a semi-rotation either at right angles to the axis of the body or in the direction of that axis; but as the *anterior* margin of the head is always found nearest the thorax, it is clear that the motion must have been of the latter kind. The rock in which the fossils occur has been pronounced by Mr. Sorby and others to be a volcanic ash, and this without reference to, or knowledge of, any speculations respecting the facts connected with the trilobites. Knowles Hill, on the flanks of which they occur, is a mass of greenstone, and is marked as such in the map published by the Geological Survey.

According to Burmeister, it is probable "that these animals (trilobites) moved only by swimming; that they swam close beneath the surface in an inverted position, the belly upwards, and the back downwards, that they made use of their power of rolling themselves into a ball as a defence against attacks from above; and that they lived gregariously in vast numbers, chiefly of one species."*

The facts connected with this fossil seem capable of explanation by supposing that a shower of volcanic ashes, falling into the ancient Devonian sea in the Newton area, alarmed a shoal of these trilobites just then swimming by, and thereby caused them instinctively to roll themselves up for defence; that the continuation of the shower, and possibly the presence of noxious gases, killed the unfortunate crustaceans in the rolled-up posture; that their centre of gravity was so situated as to cause them to sink to the bottom on their backs; that they were inhumed in the heap of ashes, which, by accumulating very rapidly in great quantity, produced a pressure sufficient to flatten the body, and, with very few and slight exceptions, the tail also; to dislocate the head (the line of union of the head and body being the line of least resistance), and, after the manner in which slaty cleavage in rocks is probably produced, to thrust it some

* Burmeister's "Trilobites," Roy. Soc. p. 52.

Fig. 2.

Fig. 1.

TRIMEROCEPHALUS LÆVIS.

Fig. 1. Body and impression of head.

Fig. 2. Head and impression of body showing the condition in which the fossil invariably occurs.
Polcarac sh., Kromle, Newton Bashelly, S. Devon.

little distance forward from the body. By such a process, the head would be inverted, and in such a way that the severed parts would take the relative positions which have been described.

All the British Devonian Cephalopoda are *Tetrabranchiate*, and every family of the order occurs amongst them. *Nautilidae* is represented by two genera, *Clymenia* and *Nautilus*. The former contained eleven species, all confined, in Devon and Cornwall, to Petherwin. The genus appears to have been restricted to Devonian times. *Orthoceratidae* also had two genera, *Orthoceras* and *Cyrtoceras*. The first contained twelve species, of which one is recorded as occurring in continental Europe, and three in carboniferous rocks. It does not appear that any have been found in Lower Cornwall or Lower North Devon. They differ much in the inclination of the sides, the septal distances, the situation and character of the siphunculus, and the inclination of the septa to the sides of the shell, though it is possible that the obliquity of the septa may have been caused by distortion, it is scarcely probable, seeing that in different specimens from different localities the amount or degree of obliquity appears to be constant. In one species the siphunculus is remarkable as forming a discontinuous line in passing from chamber to chamber. This genus was richer in species, and many attained a larger size in the Silurian and Carboniferous than in the age under consideration. *Cyrtoceras* had thirteen British Devonian species, all of which, excepting only *C. rusticum*, probably a synonym for *Orthoceras arcuatum*, are in Britain confined to South Devon. Species belonging to this genus occur before and after, but it attained its maximum specific development in, the Devonian age. The family *Ammonitidae* was represented by the single genus *Goniatites*, the first born of the family, and which dates its advent in this period, when, in the British isles, it numbered ten species, all of which are met with in Devon and Cornwall: one of them occurs in continental Europe, and three passed upwards into Carboniferous times, when the genus attained its maximum development; it outlived the Palæozoic epoch, and finally disappeared in the Triassic period.

Want of time has rendered it necessary to pass over the other classes of mollusca, as well as the entire flora of the period; and from the same cause attention has been mainly given to the Devonian beds of the South of Britain.

Though, with the exception of a scale of *Holoptychius*, found, according to Professor Phillips, at Meadfoot, near Torquay, and another at Baggy point, in North Devon, ichthyolites are not recorded as occurring in the Devonian rocks of Devon and Cornwall, it is nevertheless certain that fish did exist within the area during the period under consideration; as a fossil found a few years since in the *Stegano dictyum* beds near Looe, in Cornwall, has been pronounced by Sir Philip Egerton and other eminent palæontologists to be an ichthyodorulite, or defence-spine of a fish; and it is probable that other, though less well marked, specimens have been met with in the same district.

ROSTELLARIA CARINATA.—Mantell.
From the Gault Folkestone.
In the National Collection, British Museum.

S. J. Mackie Del.

S. P. Woodward Direxit.

The age of the world, then, which we have been considering, was comparatively a very early one ; prior to the growth of that flora of unparalleled luxuriance which has been transmuted into coal, and the deposition of the iron-stone so frequently, and in such abundance, found interstratified with the coal-beds ; a period earlier than that in which were elaborated and localized so very much of the materials containing that force, and strength, and durability which give a form and character to the civilization of our own times ;—anterior to those pages, at once historical and predictive, in which was pre-written so much of the history of countries and nations then very remotely distant in the future, and seen only by the eye of Prescience.

Yet it was by no means the *infancy* of the world ; it had been preceded by times of vast duration, represented by miles, in thickness, of sedimentary rocks ; all necessarily presupposing denudation, and, therefore, an equal amount of still more ancient rocks ; earlier times so great that in the area of modern Britain alone very nearly one thousand organic species—a thousand distinct forms of life—had performed their parts and passed into utter extinction ; not only species, but genera, families, and even orders had entirely passed away ; the world had already become old to, and for, them ; the external conditions to which they were adapted had disappeared, and had compelled their withdrawal also—gradually, slowly, and successively ; whilst their vacated niches were, one after another, occupied by new forms adapted to the new circumstances.

That the age was itself one of incalculable duration is evidenced by the facts that in some localities it is measured by fully two miles, vertical, of sedimentary matter, eminently and unmistakably detrital ; and in others by vast piles of limestone, the result of the slowly constructive labours of the small coral polype. If we may assume that then, as now, reef-building corals did not labour in depths exceeding from twenty to thirty fathoms, we are furnished with a sounding-line that enables us to fathom seas that no longer exist ; and since, in some instances, those limestone beds make up an aggregate thickness very greatly exceeding this, yet every stratum clearly the product of long-continued polype labour and industry, it appears that the Darwinian hypothesis of areas of slow and long-continued subsidence which so felicitously explains the phenomena of the coral-reefs of the Southern ocean, is equally applicable to, and equally required for, similar phenomena in the British area during the Devonian age of the world.

That it was a distinct organic period is seen by its fossils, for the most part peculiar and characteristic, yet intermediate in general facies to those of the Silurian and Carboniferous ages ; but it was not isolated from either, as some of its forms of life were derived from the former and a still greater number transmitted to the latter : the three great Palæozoic periods graduate into one another, blending as softly as do the tints of the rainbow, and emphatically deny that from the commencement of the first to the termination of the last

ICHTHYODORULITE FROM THE CHLORITIC SLATE OF
LOVE, CORNWALL.

In the Collection of W. Pengelly, F.G.S.

*Sketched from the Specimen,
On Stone by S. J. Mackie, F.G.S.*

there was any universal synchronous catastrophe or cataclysm such as to depopulate the entire world.

From some cause, at present unknown, and perhaps even unguessed, it was not an actively vital period; in fact, it fell below what may be called the normal degree of organic productiveness. Compared with those above and those below, its strata are poor in fossils in proportion to their thickness, and the genera are similarly sterile in species.

Possibly the climate was somewhat warmer than now, though the evidence of this is very treacherous. Exogenous trees existed then, and by their rings of woody matter, implying activity and stimulus, and the separability of those rings, indicating rest and the suspension of the force which causes growth, suggest the idea of changes of temperature characterized by periodicity—in fine, a change of seasons; the earth travelling round the sun under the influence of his attraction, and having then as well as now her axis inclined to the plane of her orbit.*

The beautiful patterns of the coral genera, *Heliolites*, *Acervularia*, *Smithia*, *Spongophyllum*, and others; and the exquisite forms of the *Crinoidea*, are so many revelations of the existence of beauty in those early pre-human times. So far as man is concerned—

" Full many a flower is born to blush unseen,
And waste its sweetness on the desert air."†

And then, too, animals were furnished with weapons and other means of *defence*, implying the co-existence of organs of *offence*. Violence, Fear, Terror, and Pain occupied the earth; the threads of Death were from the first inwoven in the web of Life, and the commission "to kill and eat" is as old as the organic creation.

FOSSILS IN THE "AZOIC" ROCKS.

SIR,—I hasten to communicate a new and most interesting fact regarding the oldest rocks; and I do so for the sake of securing the credit of its discovery to the excellent Keeper of the paleontological collection of the Royal Bohemian Museum, Prague—Dr. Antonio Fritsch, who well known on the continent as an authority on birds, is also an ardent paleontologist. Three summers back, he went over with me the old Silurian ground of Shropshire and the Malverns, and he convinced me that he knew his own rich district well, by the frequent comparisons he made between the different parts of

* Dr. Dawson, Quart. Jour. Geol. Soc., vol. xv., p. 485.

† Testimony of the Rocks, p. 241, &c.