the equivalent zone of *A. Burgundiae* in France are very few in number; that the Azzarola strata in Lombardy containing *Avicula contorta* have a great Madreporite-bed whose species, although differing from those of the higher members of the Infra-lias, possess the general facies of the fauna; and that the Madreporarian fauna of this period, although rich in individuals and species, does not appear to have been luxuriant.

3. On some POINTS in the STRUCTURE of the XIPHOSURA, having reference to their relationship with the EURYPTERIDÆ. By HENRY WOODWARD, Esq., F.G.S., F.Z.S., of the British Museum.

[PLATES I. & II.]

So long since as 1849 * Professor M'Coy made the proposition to unite in one tribe of the order Entomostraca the recent and fossil Limulidæ and the extinct species of *Pterygotus* and *Eurypterus*. "The tribe Pœcilopoda," he observes, "are to be distinguished from other Entomostraca by having crustaceous, didactyle, ambulatory thoracic feet, as well as membranous, respiratory abdominal ones." Professor M'Coy divides the Pœcilopoda into two divisions:—1. Limulidæ—*Limulus*; and 2. Eurypteridæ—*Eurypterus*, *Pterygotus*, and *Belinurus*. He subsequently furnished a restoration of *Pterygotus problematicus*, in illustration of his view of the anatomy of this ancient fossil remain†.

It is not surprising that Professor M'Coy should have failed to establish this order, since it was shown by Professor Huxley‡ to be founded upon an erroneous interpretation of the fossil remains; nor can it be doubted that the arrangement was based on conjecture rather than upon any minute acquaintance with the anatomy of these extinct forms of *Pterygotus* and *Eurypterus*, then only known in England by extremely fragmentary remains.

The researches, too, of Professor Huxley§ into the anatomy and affinities of the genus *Pterygotus* (in 1859) do not favour M'Coy's view of their classification under a common order or tribe with *Limulus*, although he does admit that they possess several very important points of structure in common with the latter.

"The Pœcilopoda" (*i. e.* Limulidæ), observes Professor Huxley§, "are, I believe, the only Crustacea which possess antennary organs like those of *Pterygotus*, and, like them, have the gnathites converted into locomotive organs, want the appendages to the sixth abdominal somite, and present on some parts of the body a remotely similar sculpture. In this order, however, we find but a small labrum, a rudimentary metastoma, a very differently constructed body, and a

* Ann. & Mag. Nat. Hist. 2nd ser. vol. iv. pp. 393, 394.

† Lyell's Manual of Elementary Geology, 5th. edit. 1855, p. 40. fig. 543.

‡ "On the Anatomy and Affinities of the genus *Pterygotus*," Memoirs of the Geological Survey of Great Britain, Monograph I. (1859) p. 7.

§ *Op. cit.* p. 34.

large number of appendages, both thoracic and abdominal—characters which effectually preclude the association of the extinct Crustacea under discussion with this type.”

Professor Huxley adds in a foot-note*, “If the abdominal somites of the Carboniferous *Belinurus* &c. were really free, they would present a certain approximation to the *Pterygoti*. Indeed the evidence that these Carboniferous Crustacea were true Pæcilopoda is to my mind anything but conclusive.”

The later researches of Professor James Hall, State Geologist to the State of New York (U. S.) †, into the structure and affinities of *Eurypterus* have led him to the conclusion that a close affinity exists between *Eurypterus*, *Pterygotus*, and *Limulus*; and he also cites the opinion of Professor Agassiz‡, “that the *Eurypteri* are closely related to *Limulus*, belonging even to the same order.” “He regards the antennal system as entirely absent. The organs of locomotion belong to the cephalic region; and while externally they perform the functions of feet, they are, at the base, organs of manducation. The central organ [Pl. II. fig. 8, *a*], indicated as a locomotive appendage [*operculum*’ of Professor Huxley (see Med. Times & Gazette, 1857), Professor Agassiz regards as similar to the appendage attached to the membranaceous feet, behind the swimming-feet of *Limulus* [Pl. II. fig. 7, *a*], and instead of being double, is ankylosed as in young *Limulus*” §.

Professor Nieszkowski || (in Russia) appears to have arrived, about the same time as Professor Hall (1859), at somewhat similar conclusions, only that he has made out a series of *three* thoracic membranous plates *all sculptured* upon their surface. This could not be the case, however, had they *overlapped* each other as in the recent *Limulus*; for surfaces that are covered by other overlying organs are destitute of ornamentation.

Much later (*i. e.* in 1863) I made an examination of these forms, and, without being thoroughly acquainted with the foreign bibliography of the subject, I arrived independently at the same conclusion with Professors Agassiz and Hall ¶. In 1864 and 1865 I continued my researches; and some of the results have already appeared in the Journal of this Society and elsewhere **.

Having devoted some time to the examination of the (so-called) fossil Limulidæ of the Coal-measures, I think I shall be able to show that we have evidence of some, at least, of the intermediate forms that were absolutely needed in order to establish a relationship be-

* *Op. cit.* p. 34.

† Nat. Hist. New York: Palæontology (1859), vol. iii. p. 393.

‡ *Op. cit.* p. 394.

§ *Op. cit.*

|| Archiv für die Naturkunde Livonia, Esthonia und Kurlands, 1st series, vol. ii. p. 299, pls. 1 & 2: Dorpat, 1859.

¶ See the Intellectual Observer for 1863 (vol. iv. p. 229).

** See (*a*) Geol. Mag. vol. i. p. 196, pl. x., and p. 239. See also (*b*) Lyell's Elements of Geology, 6th edit. (1865), p. 524, fig. 591. See also (*c*) Quart. Journ. Geol. Soc. 1865, vol. xxi. p. 482, pls. xiii. & xiv. See also (*d*) British Association Reports, 1864-65, Bath and Birmingham.

tween the Limulidæ of to-day and the extinct Eurypteridæ of Palæozoic times.

In *Pterygotus*, *Eurypterus* (see Pl. I. fig. 7, *Eurypterus remipes*), &c. the animal consists of a head, bearing a pair of minute larval eyes and a larger pair of subcentral or marginal compound ones, a pair of simple or chelate antennæ (Pl. II. fig. 9), furnished with gnathites in *Eurypterus* and *Slimonia* (Pl. II. fig. 10), three pairs of more or less slender spinous pedipalps, *never chelate*, and a pair of very broad and powerful swimming-feet (Pl. I. fig. 7, *e*), whose basal joints form powerful mandibles. In *Stylonurus* the two posterior pairs of appendages are converted into long and slender rowing-organs.

Following this compound head are twelve free segments, only the first two (?) of which bear appendages (Pl. II. fig. 8), the succeeding somites being apparently destitute of any. The twelve free segments are followed by a postanal plate or "telson," broadly lanceolate or bilobed in *Pterygotus* and *Slimonia*, and ensiform in *Eurypterus* and *Stylonurus* (Pl. I. fig. 7, *r*).

In *Limulus* (Pl. II. figs. 1 & 2) the head is composed of a broad buckler having the larval and compound eyes upon its superior or convex surface, and the mouth, surrounded by six pairs of chelate appendages, placed beneath the head-shield (Pl. II. fig. 6). The first pair of appendages is placed in front of, and the four succeeding pairs are posterior to the mouth. These latter are furnished with spinous gnathites, the most posterior pair serving as *maxillæ*.

Next follows the *operculum* or thoracic plate (Pl. II. fig. 7), which is attached to the posterior margin of the head, and bears upon its inner and upper surface the reproductive organs or ovaries (Pl. II. fig. 7, *r*).

The six anchylosed segments which compose the posterior portion of the body bear five lamellar appendages upon their under surface, similar in shape to the operculum, but more membranous; these support the gills, and are partially hidden beneath the operculum.

The body terminates in a long ensiform "telson," or tail-spine. The anterior portion here spoken of as the head has always been regarded as representing the cephalothorax, and the posterior portion as the abdomen; this latter I propose to call the thorax (*in part*), and to give my reasons for so doing as we proceed.

The great and apparent difference between *Limulus* (Pl. II. figs. 1 & 2) and *Eurypterus* (Pl. I. fig. 7) is, that in the latter one sees fourteen free segments or divisions, whilst in the former only three are visible. But if we examine *Limulus* attentively we can still trace in the posterior portion of its shell (Pl. II. figs. 1 & 2) indications of segmentation, whilst the presence of thirteen paired appendages indicates the coalescence of numerous segments.

The points of resemblance are:—the larval eye-spots; the adult subcentral eyes; the jaw-feet, serving as the sole locomotive organs, the basal joints in the posterior pair being especially fitted for manducation, and the posterior limbs for swimming; the analogous position of the opercular plate, covering, no doubt, in the fossil

Pterygotus, as in the recent *Limulus*, the reproductive organs, and succeeded, no doubt, in both, by similarly formed membranous appendages bearing branchiæ.

This latter point, I think, is established on the evidence of specimens both in the Museum of Practical Geology and in the British Museum, showing two opercular-shaped plates associated together (Pl. II. fig. 11) and evidently belonging to the same individual. One plate also exhibits two small rounded prominences, which, there can be little doubt, were ovarian openings.

If the head in *Limulus* be composed of the cephalothorax, and the posterior portion be the abdomen, then it follows that the opercular plate is thoracic, and the succeeding branchial plates are abdominal, thus differing widely from the fossil forms, in which the head is simply the head, with one thoracic segment added to it bearing the opercular plate; the branchiæ are thoracic, and the abdomen is entirely destitute of appendages.

Let it be granted, however, that the head in *Limulus* represents the entire cephalothorax and the posterior portion the abdomen; if specimens can be shown having a "postabdominal" series of segments, I think it will be conceded by all carcinologists that in *Limulus* the abdomen is rudimentary, as is the case in *Cyclops*, *Daphnia*, *Lernæa*, &c., and in the Brachyurous Decapods.

In 1864 I exhibited at the Bath Meeting of the British Association a form which I named *Hemiaspis* (Pl. I. fig. 3; and Quart. Journ. Geol. Soc. 1865, vol. xxi. p. 490, pl. xiv. fig. 7, *a, b*)*. We have in *Hemiaspis* a limuloid crustacean, having a head-shield, six free and moveable segments forming the thorax, and three very narrow, and apparently double, segments representing the abdomen, followed by a long and slender "*telson*."

Since describing the above remarkable form, I have lately procured a paper, published at Dorpat, by Dr. J. Nieszkowski†, by which I have become acquainted with two new forms from the Upper Silurian of the Island of Oesel, which must be added to the list of forms allied to *Hemiaspis*. They are named by Dr. Nieszkowski *Pseudoniscus aculeatus* (Pl. I. fig. 5) and *Exapinurus Schrenkii* (Pl. I. fig. 6).

Professor Eichwald has described another, which, no doubt, is related to this group of Crustacea, namely *Bunodes lunula* (Pl. I. fig. 4). All these forms have *three* well-marked divisions to their bodies, of head, thorax, and abdomen; and all, save *Bunodes*, possessed a *telson*, or tail-spine, and free articulated thoracic somites.

Having been favoured with the loan of the very beautiful series of Coal-measure *Limuli* belonging to our Treasurer, J. Prestwich, Esq., F.R.S., and also with a series from the Broseley Institute, and

* I avail myself of this opportunity to correct an error in the description of *Hemiaspis limuloides*. The portion figured as *b* on the plate referred to, and described as the centre of the glabella, is in reality that of another species, the glabella in this species being nearly smooth, as in the figure given herewith, drawn from a specimen in the late Mr. H. Wyatt-Edgell's collection.

† *Op. et loc. cit.* pp. 380, 381; and p. 384, figs. 12-15.

a third suite from the collection of John Anstice, Esq., of Madeley Wood, Wellington, Salop, together with specimens from Mr. E. J. Hollier, of Dudley, and Mr. J. Farie, of Glasgow, I have, after careful study, concluded that they are divisible into *two well-marked genera*:—

(a) Those having moveable thoracic segments and anchylosed abdominal ones, to be included in the genus *Belinurus*, namely—

1. *Belinurus trilobitoides*, Buckl. Coal-measures, Derry and Coalbrook Dale.
2. ——— *reginæ*, Baily (Pl. I. fig. 1). Coal-measures, Ireland.
3. ——— *arcuatus*, Baily. Coal-measures, Ireland.
- 4.? ——— *Danæ*, Meek & W. Coal-measures, Illinois, U.S.

(b) Those in which the thoracic and abdominal segments are not divided and in which the former appear to be anchylosed, to be included in a new genus, for which I venture to propose, if Mr. Prestwich will allow me, the name of *Prestwichia*; i. e.:—

1. *Prestwichia anthrax*, Prestw., sp. Coal-measures, Coalbrook Dale.
2. ——— *rotundata*, Prestw., sp. (Pl. I. fig. 2). Coal-measures, Coalbrook Dale.

In all these six species the body consists of a head-shield, five free, or anchylosed, thoracic segments, and three anchylosed abdominal ones.

Here, then, we have an intermediate group between *Limulus* proper, more nearly approaching *Hemiaspis* &c., but having the posterior (or abdominal) segments anchylosed together, and not freely articulated as they appear to have been in *Hemiaspis* and *Pseudoniscus* &c. Furthermore the six free thoracic segments are reduced to five in *Belinurus* (Pl. I. fig. 2).

In the recent *Limulus* we find thirteen paired appendages, representing an equal number of somites, behind which there is seen one or more coalesced segments destitute of appendages, to the last of which the telson is articulated (see Pl. II. figs. 1 & 2, *Ab.*).

I feel no doubt that this apodal posterior portion of the integument in *Limulus* represents the abdomen, and corresponds with the three posterior coalesced segments forming that division in *Belinurus* (Pl. I. fig. 1, *Ab.*). The fossil species well illustrate the gradual coalescence of the body-segments in this family.

Belinurus reginæ, Baily (Pl. I. fig. 1) (Ann. & Mag. Nat. Hist. 3rd ser. (1863) vol. xi. p. 107, pl. 5), is one of the best illustrations of a Crustacean with free thoracic segments, and *Prestwichia rotundata* (Pl. I. fig. 2) of one in which the segments are coalesced. All the group possess, in the trilobed aspect and general facies of the carapace, a strong resemblance to the *Trilobita*; but this resemblance becomes still more striking when we observe their tripartite division into head, thorax, and abdomen.

Nearly all writers agree in considering the last seven somites (counting the "telson" as the seventh) to be abdominal; the only

difference of opinion, then, is as to the anterior 14 segments—how many are cephalic and how many thoracic?

Dr. Dana* considers the head and thorax in the Crustacea to be always blended in a cephalothorax; but although this view is correct as regards the Decapoda, its applicability does not hold good in all the other orders of the class.

Professor Huxley† considers that the division in the Podophthalmia is marked by the cervical fold and by the sudden change in the character of the appendages of the sixth and seventh somites, and an equally marked similarity between the latter and those of the eighth and ninth somites.

According to this view, then, we shall have six cephalic, eight thoracic, and six abdominal somites; for Professor Huxley views the telson as a median appendage, and not as a true segment. I do not find, however, that this view is generally adopted by other carcinologists.

Assuming the old view of the Crustacean type to be correct, *i.e.* seven somites for the head, seven for the thorax, and seven for the abdomen (counting the telson as a terminal segment, on which point there is no doubt some uncertainty, seeing that in *Limulus* it is developed subsequently, though this is not the case in the Decapoda), we shall find that the first thoracic somite is united to the cephalon in *Limulus* (bearing the operculum), that there are only five other appendages to the thorax, making six with the operculum, and that there are no appendages to the abdomen.

Of the appendages belonging to *Belinurus*, *Prestwichia*, *Hemiaspis*, *Pseudoniscus*, *Excapinurus*, and *Bunodes*, I cannot speak with certainty, but can only infer, from the general similarity in their bodies of the first two genera to *Limulus*, and of the last four to *Eurypterus*, that they were constructed upon those types.

Turning from *Limulus* to *Pterygotus*, we find that Professor Agassiz regards the antennary system as altogether wanting (see *ante*, p. 29); but in this we cannot but think he is mistaken. Professor Huxley regards the chelate organs on the head of *Pterygotus* as the antennæ; and this opinion agrees well with subsequent discoveries in the fossil forms on the one hand, and with the nature of these organs in the recent *Limulus*. The antennules undergo no sexual variation in the living King-crabs, it is invariably the antennæ that are modified. (See Pl. II. fig. 5, antenna of male King-crab; fig. 6, antenna of female of same.)

Assuming the antennules to be absent, and the first pair of organs after the eyes to be the antennæ, we shall find the other organs to correspond most completely with *Limulus*, and that one thoracic segment is united to the head of *Pterygotus*, as in the former, and that it also bears the reproductive organs upon its coalesced membranous appendages.

The branchiæ would, however, be fewer in *Pterygotus* than in *Limulus*, but similarly placed—resembling in this respect the immature condition of the latter. (See Pl. II. fig. 4.)

* United States Exploring Expedition, 1852: Crustacea, vol. xiii. p. 21.

† "Lectures on the Crustacea," Medical Times and Gazette, 1857, p. 507.

In the development of the embryo of any of the Crustacea, whether before or after exclusion from the egg, the segments which form the body are developed in succession from before backwards; so that when their evolution is checked, the posterior rather than the anterior rings are those that are wanting; and, in fact, it is generally easy to see in those specimens of full-grown crustaceous animals whose bodies present fewer than 21 segments, that the anomaly is due to the absence of a certain number of the most posterior rings of the body. [See Milne-Edwards on the development of Crustacea.]

So long ago as 1838, Dr. Milne-Edwards* gave an account of an examination of the young of *Limulus* at the time of its extrusion from the egg. He found that, as regards the anterior portion of their bodies, they presented little difference from the adult; but the posterior portion had only three pairs of appendages; and the long styliform telson, so remarkable in the adult, did not exist at all. [See Pl. II. figs. 3 & 4.]

It is, then, I think, reasonable to assume that the absence of the normal number of segments in *Limulus* is due to the abortion or non-development of the hindmost abdominal somites rather than of those belonging to the other divisions of the body.

As to the union of two dissimilar parts, so as to leave no indication of their blending, there are numerous cases in the Cyclopoidea, as well as in other orders. In *Cyclops* the ovarian segment is double, being formed by the coalescence of the last thoracic and the first abdominal somites. In *Corycaeus crassiusculus* eight segments unite to form the head, as is the case in *Limulus*—i. e. seven cephalic and one thoracic somites.

Taking the Eurypterida first, we find five genera and one sub-genus, having a head bearing seven paired appendages, and (adopting Professor Huxley's view, that the antennules or inner antennæ are absent) representing eight segments (i. e. seven cephalic and one thoracic). Add to this the twelve free body-segments and the telson, and we have twenty-one, or the normal number of somites. With the exception of the two most anterior segments (which probably had branchial appendages attached to their under surfaces, concealed beneath the operculum or thoracic plate), all the free somites are destitute of limbs of any kind; and in this respect they strongly resemble the larvæ of the Decapoda†.

In *Hemiaspis* we have the body composed of a head, six thoracic and three abdominal somites, and a telson.

In *Exapinurus* and *Pseudoniscus* of a head, five thoracic and four abdominal somites, and a telson.

In *Belinurus*, a head, five thoracic and three abdominal somites, and a telson.

In *Prestwichia*, a head, five thoracic and three abdominal somites, and a telson.

* "Sur le développement des *Limules*," Société Philomathique, Nov. 10, 1838.

† See Mr. C. Spence Bate "on the Development of Decapod Crustacea," Phil. Trans. 1858, p. 589, pl. xl. figs. A & B.

In *Limuli* from Solenhofen and in the living *Limuli*, of a head composed of eight somites (one being thoracic), followed by five coalesced thoracic somites bearing branchiæ, and one or more coalesced abdominal ones, to which is articulated a long and pointed telson.

In proposing to associate the Eurypterida and Xiphosura as two suborders of the Merostomata of Dana*, I do not for a moment overlook the fact that they form two very distinct although closely allied groups.

Notwithstanding the great difference in the form of the body, concentrated and coalesced in *Limulus*, and elongated in *Pterygotus*, the Merostomata offer perhaps even less diversity of structure than do the Decapoda, the main feature in both being the same. Thus, in the Decapoda Brachyura (Crabs) we have the cephalothoracic segments concentrated in the highest degree, and the abdomen a mere rudiment. In the Decapoda Macrura (Lobsters), on the contrary, the abdominal segments are not unfrequently more than twice the length of the cephalothorax, and bulky in proportion.

Such forms as *Hemiaspis*, *Pseudoniscus*, &c. may very well represent the Decapoda Anomura, being, like them, intermediate between the long-tailed Lobsters and the short-tailed Crabs.

Few classes offer so remarkable an instance of longevity as the Crustacea, and few orders can be compared to the Xiphosura for persistency. The Jurassic forms appear to differ little, if at all, from those of our own day; and even those of the Carboniferous epoch were at once recognized as belonging to the same family.

Had *Limulus* represented a higher type of Articulata, it is hardly conceivable that it could have existed so long, and apparently unchanged. But it seems to have been one of those eccentric groups that appear from time to time in the zoological series, which, branching out into a by-way of its own, is checked from further onward progress; but being possessed of tenacity of life and great power of reproduction, it holds its ground whilst higher orders have been modified or swept away.

This is one very strong argument, to my mind, in favour of the higher zoological position of *Pterygotus*—that, being extremely larval in its anatomy, it consequently possessed the capacity for further development, and so has been modified and disappeared, *Eurypterus Scouleri* of the Coal-measures being its latest representative.

It is not uninteresting to notice the appearance of Scorpionidæ in the Coal-measures of Silesia, a form of Arachnida which to this day possesses a very remarkable resemblance to *Pterygotus*, both in its general shape and also in the arrangement of its organs.

But in *Scorpio* the respiration is aerial (*i. e.* by tracheæ), whereas in *Limulus* and *Pterygotus* it was undoubtedly aquatic (*i. e.* by branchiæ).

This would, however, be a perfectly parallel case to the change

* See my 'Monograph of the British Fossil Crustacea belonging to the order Merostoma,' Part I., in the Monographs of the Palæontological Society, for 1865. 1866.

which takes place in the respiratory organs of certain Amphibia, in which the branchiæ become replaced by a lung.

The following is a diagnosis of the

Order MEROSTOMATA, Dana, 1852.

Having the mouth furnished with mandibles and maxillæ, the terminations of which become walking- or swimming-feet and organs of prehension.

I. Suborder EURYPTERIDA, Huxley, 1859.

Crustacea with numerous free thoracico-abdominal segments, the first and second (?) of which bear one or more broad lamellar appendages upon their ventral surface, the remaining segments being devoid of appendages; the anterior rings united into a carapace bearing a pair of larval eyes (*ocelli*) near the centre, and a pair of large marginal or subcentral eyes; the mouth furnished with a broad postoral plate, or *metastoma*, and five pairs of moveable appendages, the posterior of which form great swimming-feet; the telson, or terminal segment, extremely variable in form; the integument characteristically sculptured.

1. <i>Pterygotus</i> , Agassiz	16 species.
2. <i>Slimonia</i> (Page), H. Woodw.	3 "
3. <i>Stylonurus</i> (Page), H. Woodw.	6 "
4. <i>Eurypterus</i> , De Kay	22 "
Subgenus <i>Dolichopterus</i> , Hall	1 "
5. <i>Adelophthalmus</i> , Jordan	1 "
6. <i>Bunodes</i> , Eichw.	2 "
7. <i>Arthropleura</i> , Jordan	3 "
8. <i>Hemiaspis</i> , H. Woodw.	6 "
9. <i>Ecapinurus</i> , Nieszk	1 "
10. <i>Pseudoniscus</i> , Nieszk	1 "
	<hr/>
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II. Suborder XIPHOSURA, Gronovan, 1764.

Crustacea having the anterior segments welded together to form a broad convex buckler, upon the dorsal surface of which the compound eyes and ocelli are placed, the former subcentrally, the latter in the centre in front; the mouth furnished with a small labrum, a rudimentary metastoma, and six pairs of moveable appendages. Posterior segments of the body more or less free, and bearing upon their ventral surfaces a series of broad lamellar appendages; the telson or terminal segment ensiform.

1. <i>Belinurus</i> (König), Baily	4 species.
2. <i>Prestwichia</i> , gen. nov.	2 "
3. <i>Limulus</i> , Müller	15 "
	<hr/>
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Of the Eurypterida, 49 species occur in the Upper Silurian, 18 in the Devonian, and 10 in the Carboniferous formation. Of the Xiphosura, 6 occur in the Carboniferous, 1 in the Permian, 1 in the

Trias, 7 in the Oolitic, 1 (doubtful) in the Chalk, and 1 in the Tertiary; and there are 4 recent species.

They occur living in the East Indies, in Japan, and on the east coast of North America—and fossil in North America, Great Britain and Ireland, Scandinavia, Russia, Poland, and Germany.

EXPLANATION OF PLATES I. & II.

Illustrative of the Structure of the Xiphosura and Eurypterida.

PLATE I.

- Fig. 1. *Belinurus reginæ**, Baily. Coal-measures, Queen's County, Ireland. H.=Head; Th.=Thorax; Ab.=Abdomen; T.=Telson.
2. *Prestwichia (Limulus) rotundata*, Prestw. sp. Coal-measures (Penny-stone ironstone), Coalbrook Dale.
3. *Hemiaspis limuloides*, H. Woodw. Lower Ludlow shale, Leintwardine. (From the late Mr. H. Wyatt-Edgell's collection.)
4. *Bunodes limula*, Eichw. Upper Silurian, Isle of Oesel, Baltic.
5. *Pseudoniscus aculeatus*, Nieszk. Upper Silurian, Isle of Oesel, Baltic.
6. *Exapinurus Schrenkii*, Nieszk. Upper Silurian. Isle of Oesel, Baltic. (Figs. 4-6 are copied from Dr. Nieszkowski's paper in the Archiv für die Naturk. Liv-, Esth., und Kurl.-erste Serie, zweiter Bd. tab. ii. figs. 12, 13, & 15, pp. 378-382. Dorpat, 1859.)
7. *Eurypterus remipes*, Dekay. Upper Silurian, New York. (Copied from Hall's 'Palæontology of New York,' vol. iii. pl. lxxiv. a. fig. 1.)

PLATE II.

- Fig. 1. Carapace of *Limulus polyphemus* (recent). East coast of North America. Showing the larval and compound eyes. H.=Head; Th.=Thorax; Ab.=Abdomen; T.=Telson.
2. Underside of same, showing indications of the coalesced thoracic and abdominal somites, and the processes for the attachment of the appendages.
3. The first stage of *Limulus* (young), dorsal aspect.
4. Underside of the same, enlarged (after Milne-Edwards).
5. Club-shaped antenna of male *Limulus*.
6. Chelate antenna of female *Limulus*.
7. Operculum of recent *Limulus*. r, reproductive apertures.
8. Operculum of *Eurypterus* (Hall).
9. Chelate antenna of *Pterygotus*.
10. Simple antenna of *Simonia*.
11. Specimen from Lanarkshire in the British Museum collection (reduced to one-fourth), showing two thoracic plates of *Simonia* associated together.

DECEMBER 5, 1866.

C. J. H. Allen, Esq., F.Z.S., 4 Park Crescent, N.W.; Henry Pitts Cassidy, Esq., Engineering College, Poona; Robert Etheridge, Jun., Esq., of the Geological Survey of Victoria, Australia; Marshall Hall, Esq., 3 Cleaveland Terrace, Hyde Park, W.; Alfred Gutters Henriques, Esq., F.Z.S., Stone Buildings, Lincoln's Inn, W.C.; Henry Lainson, Esq., Heath House, Reigate, Surrey; Dr. James Murie, 20 Regent's Park Road, N.W.; and John W. Pike, Esq., Mining Engineer, Mexico, were elected Fellows.

* Ann. & Mag. Nat. Hist. 1863 (3rd Series), vol. xi. p. 107, pl. v.

G. Massee, del. et lith.

M. & N. Hanhart imp.

PRESTWICHIA, BELINURUS, HEMIASPIS, &c.

G. Massee del et inc.

M. N. Hardhart imp.

LIMULUS, EURYPTERUS, SLIMONIA, &c.

The following communications were read:—

1. A DESCRIPTION of some ECHINODERMATA from the CRETACEOUS ROCKS of SINAI. By P. MARTIN DUNCAN, M.B. Lond., Sec. G. S.

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1. *Introduction*.—The existence of Cretaceous rocks in the district of Sinai has been surmised for several years; but hitherto the correct geological denomination of the strata has not been ascertained. They have been simply termed Cretaceous; and, owing to the scarcity of fossils, they have not been correlated with any of the Asiatic formations.

An examination of the series of Echinodermata collected by the Rev. F. W. Holland, from the limestones of Wady Mokatteb and Wady Badera*, readily decides the geological age of the rocks, and enables them to be correlated with those red limestones in South-eastern Arabia whose fossils were described in a former communication†.

Had these Sinaitic Echinodermata been in my possession during the preparation of that communication, their study would have made it much more complete; but coming before my notice now, their examination presents several tests in reference to the correctness of my conclusions. It is satisfactory that this examination should strengthen all those conclusions, and that it should determine the presence of the same zone of Echinodermal life in Southern India, on the Nerbudda, in South-eastern Arabia, Sinai, Egypt, Algiers, and in North-western Europe. Moreover the remarks made upon the variability of the species described in the former communication receive additional strength, and the correctness of placing all the localities formerly noticed, with the Sinaitic chalk, in the Middle Cretaceous series, or in that which comprises the Cénomanien and Turonien stages, becomes apparent.

The few Echinodermata described by Desor and d'Orbigny from Sinai appear to be peculiar to that region; but all those collected by Mr. Holland are well-known forms, and are characteristic of the typical Upper Greensand of France, England, and Ireland.

The facies of the collection is that of the South-eastern Arabian and Bagh series; so that nothing can be more complete than the correspondence of the united Asiatic Echinodermata with those of the zones of *Pecten asper*, *Pygurus lampas*, *Scaphites æqualis*, *Ammonites navicularis* and *Ostrea columba* in North-western Europe.

2. *List of the species of Echinodermata*.—The following is the list of the Echinodermata from Wady Mokatteb and Wady Badera. The localities and zones of the accompanying fossils, where they are found elsewhere, are also given:—

* Quart. Journ. Geol. Soc. vol. xxii. p. 491, and note at the end of this paper.

† Quart. Journ. Geol. Soc. vol. xxi. p. 349.

1. *Pseudodiadema Rüppelli*, Desor. Egypt.
2. *Heterodiadema libycum*, Ag. & Desor, sp. Egypt. Batna in Algiers; Martigues, France. Zone of *Ostrea columba*. Martigues, France, below the zone of *Caprina adversa*.
3. *Holcotypus excisus*, Desor, sp. Le Mans; Ile d'Aix. Zone of *Turritiles costatus* and *Pygurus lampas*.
4. *Periaster elatus*, d'Orb. Le Mans; Yvre l'Évêque. Zone of *Ammonites navicularis*.
5. *Hemiaster gracilis*, Cotteau. Yvre l'Évêque. Zone of *Ammonites navicularis*.
6. *Epiaster distinctus*, d'Orb. South-east Arabia, with *Hemiaster similis* *Cidaris cenomanensis* and *Pygaster truncatus*. Ireland; Cornes and Villiers, France. Zone of *Pecten asper* (upper part).

3. List of the species already described from Sinai:—

1. *Diplopodia Sinaica*, Desor, sp.
2. *Claviaster cornutus*, d'Orb.
3. *Pedina Sinaica*, Desor.

4. List of the species from South-eastern Arabia:—

1. *Cidaris cenomanensis*, Cotteau. Yvre l'Évêque. Zone of *Scaphites æqualis*.
2. *Pseudodiadema Roemeri*, Desor. Hildesheim.
3. *Salenia scutigera*, Gray. Warminster; Le Mans. Zone of *Scaphites æqualis*.
4. *Holcotypus cenomanensis*, Guéranger. Texas; Le Mans. Zone of *Pygurus lampas*.
5. *Pygaster truncatus*, Agassiz. North Ireland; Condrecieux. Zone of *Pecten asper*.
6. *Epiaster distinctus*, d'Orb. Sinai; Ireland; Cornes. Zone of *Pecten asper*.
7. *Hemiaster similis**, d'Orb. Bagh; Le Mans. Zone of *Ammonites navicularis*.
8. *Cottaldia Carteri*, nobis.

Combining, then, the Sinaitic and south-east Arabian Echinodermata, a fauna is produced which is eminently characteristic of the middle cretaceous horizon.

5. *Remarks on the species, their persistence and variability.*—The *Holcotypus* from Sinai, formerly termed a *Discoidea*, is found in three forms. One cannot be distinguished from the type of *H. excisus*; and the others are simple varieties, their size being the presumed variation.

Periaster elatus is found as a slight variety, and *Epiaster distinctus* also.

The vertical range of *Heterodiadema libycum* is worthy of notice, because it resembles that of some of the South-east Arabian Echinodermata. The species lasted during the Hippuritic chalk age, as well as during the antecedent Cénomanien.

The comparative absence of species unknown in Europe is somewhat remarkable; and so is the presence of some of the rarer Echinodermata of the well-searched French district of La Sarthe. It is very interesting to discover that the majority of these wide-wandering Echinodermata had a tendency to vary from their types, both in Europe and in Arabia, and that the rest were persistent in form.

In conclusion, I must refer to the remarks upon the diffusion and

* M. Hébert determines this species to be identical with *H. Leymeri*.

variability of the middle cretaceous Echinodermata made in my former communication.

NOTE.—The Rev. H. Holland informs me that in the Wady Badera the Echinodermata occurred in the bed of the Wady, having evidently been washed down from a bed of limestone which exists near the pass at its head. This pass is composed of variegated sandstone rocks resting upon gneiss. The sandstone occurs at a higher elevation than the limestone; but the exact position of the latter I did not remark. The Echinoderms from Wady Mokatteb were found in a small bed of limestone at the foot of Jebel Mokatteb, which crops out beneath a sandstone.

2. GEOLOGICAL DESCRIPTION of the FIRST CATARACT, UPPER EGYPT.

By J. C. HAWKSHAW, Esq., F.G.S.

[The publication of this paper is unavoidably deferred.]

(Abstract.)

At the First Cataract the Nile flows over crystalline rocks consisting principally of quartz, felspar, and hornblende, combined in various proportions, and then appearing under the forms of syenite, greenstone, hornblende, and mica-schists, or else occurring in separate masses. In the bed of the river the surface of the harder portions of these rocks is beautifully polished. The whole district is traversed by dykes of greenstone, of which the prevailing direction is E. and W.

The crystalline rocks forming the bed of the river are overlain by a sandstone, sometimes coarse and gritty, and at other times fine-grained and compact. The prevailing colour is light yellow; but in places it is dark-purple and even black, owing to the presence of iron. As yet no organic remains have been discovered in it. This sandstone rests on the uneven surface of the syenite, in slightly inclined strata dipping N.N.E. It is nowhere altered at its junction with the syenite, nor is it anywhere penetrated by dykes.

To the eastward of the First Cataract is a wide valley, commencing opposite the Island of Philæ, and joining the Nile valley again about three miles below Assouan. Through this valley the Nile may have formerly flowed, as freshwater shells and deposits of Nile-mud are found at a considerable height above the present level of the river.

To the westward of the First Cataract the crystalline rocks disappear below the sandstone, and the country is almost entirely covered with sand of a rich yellow colour, composed of fine rounded grains of quartz.

3. On the DRIFT of the NORTH of ENGLAND. By J. CURRY, Esq.

(Communicated by the Assistant-Secretary.)

[Abstract.]

THE Drift under consideration is stated to occupy certain slopes from the following mountain-eminences, namely:—Skiddaw, Saddle-